Results of the Annual Trawl Surveys of Juvenile Flatfish in Hecate Strait, 1980-85

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RESULTS OF THE ANNUAL TRAWL SURVEYS OF JUVENILE FLATFISH IN HECATE STRAIT, 1980-85.

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by

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ABSTRACT

Fargo, J. and S. J. Westrheim. 1986. Results of annual trawl surveys of juvenile flatfish in Hecate Strait, 1980-85. Can. MS Rep. Fish. Aquat. Sci. 1884: 71 p.

Six annual trawl surveys were completed in Hecate Strait during August 1980-81 and April 1982-85, to obtain relative and absolute abundance indices for juvenile groundfish, primarily English sole (Parophrys vetulus) and rock sole (Lepidopsetta bilineata). Additionally, modest experiments were conducted concerning trawl-haul replications and trawl-gear variations.

Principal species caught, in addition to the two target species, were Pacific cod (Gadus macrocephalus), Pacific halibut (Hippoglossus stenolepis), skates (principally Raja binoculata), and spiny dogfish (Squalus acanthius). Total species caught per survey ranged from 21-30. Length measurements were collected from 19 species (46,235 measurements), but data sufficient for assessing abundance of juvenile age-classes was only available for English sole, rock sole, and Pacific halibut.

Comparative daylight hauls revealed substantial heterogeneity in catch rates of juvenile English and rock soles. Pacific halibut catches were too small to be tested. Comparison of day vs night hauls revealed that catch rates of age-1 and age-2 rock sole, but not English sole, were consistently larger at night.

The small-mesh cod-end liner provided no advantage in catching age-1 and age-2 English sole and rock sole, and was less effective catching age-1 English sole. The combination of small-mesh cod-end plus a tickler chain produced mixed results. The survey (shrimp) trawl was more effective on juvenile fish than a commercial (flatfish) trawl.

Relative abundance indices (geometric mean nos./h; square root of 0-catch frequency) exhibited poor correlation among age-classes within year-classes for English and rock soles.

Absolute abundance indices (nos. of fish on the ground) indicated that the most abundant year classes were probably 1984 for English sole (2,855,000 fish at age 1); and 1978 for rock sole (2,014,000 fish at age 2) and Pacific halibut (1,281,000 fish at age 3; 1,213,000 fish at age 4). Least abundant year-classes were probably 1980 for English sole (428,000 at age 1; 278,000 at age 2); 1983 for rock sole (181,000 fish at age 1; 468,000 fish at age 2); and 1982 for Pacific halibut (138,000 at age 3).

RESUME

Fargo, J. and S. J. Westrheim. 1986. Results of annual trawl surveys of juvenile flatfish in Hecate Strait, 1980-85. Can. MS Rep. Fish. Aquat. Sci. 1884: 71 p.

Six relevés annuels par chalutage ont été réalisés dans le détroit d'Hécate au cours des moins d'août de 1980 et 1981 et des mois d'avril de 1982 à 1985 afin d'obtenir des indices de l'abondance relative et absolue des juvéniles de poissons de fond, surtout ceux de la sole anglaise (Parophryx vetulus) et de la sole du Pacifique (Lepidopsetta bilineata). Des essais sommaires portant sur la duplication des résultats des traits de chalut et sur les chaluts ont aussi été effectués.

Les principales espèces capturées, en plus des espèces visées, étaient la morue du Pacifique (Gadus macrocephalus), le flétan du Pacifique (Hippoglossus stenolepis), des raies (surtout Raja binoculata) et l'aiguillat commun (Squalus acanthius). Le nombre total d'espèces capturées par relevé variait de 21 à 30. La longueur des poissons de 19 espèces a été déterminée (46 235 mesures), mais on ne disposait de données suffisantes que pour l'évaluation de l'abondance des classes d'âge des juvéniles de la sole anglaise, de la sole du Pacifique et du flétan du Pacifique.

Des chalutages de jour comparatifs ont montré l'existence d'une hétérogénéité appréciable au sein des taux de prise des soles juvéniles anglaise et du Pacifique. Les prises de flétan du Pacifique étaient trop petites pour être analysées. La comparaison des chalutages diurnes et nocturnes a montré que les taux de prise des soles du Pacifique d'âges 1 and 2, mais non ceux des soles anglaises, étaient constamment plus élevés la nuit.

Une doublure de cul-de-chalut à petites mailles n'a pas permis de capturer plus de soles anglaises et de soles du Pacifique des âges 1 et 2 et s'est avérée moins efficace pour la capture des soles anglaises d'âge 1. L'utilisation combinée de la doublure à mailles fines et d'une chaîne gratteuse a donné des résultats variables. Le chalut utilisé pour les relevés (chalut à crevettes) était plus efficace que le chalut commercial (poissons plats) pour la capture des poissons juvéniles.

Les indices d'abondance relative (moyenne géométrique/h; racine carrée de la fréquence de prise 0) étaient mal corrélés entre les classes d'âge de mêmes classes annuelles tant pour les soles anglaises que celles du Pacifique.

Selon les indices d'abondance absolue (nombre de poissons sur le fond), les classes annuelles les plus abondantes étaient celles de 1984 pour la sole anglaise (2 855 000 poissons d'âge 1), de 1978 pour la sole du Pacifique (2 014 000 poissons d'âge 2) et le flétan du Pacifique (1 281 000 poissons d'âge 3; 1 213 000 poissons d'âge 4). Les classes d'âge les moins abondantes étaient probablement celles de 1980 pour la sole anglaise (428 000 poissons d'âge 1 et 278 000 poissons d'âge 2), de 1983 pour la sole du Pacifique (181 000 poissons d'âge 1 et 468 000 poissons d'âge 2) et de 1982 pour le flétan du Pacifique (138 000 poissons d'âge 3).

INTRODUCTION

English sole (Parophrys vetulus) and rock sole (Lepidopsetta bilineata) are important components of the trawl fishery in Hecate Strait, British Columbia (Fig. 1). During 1956-84, landings of English sole have ranged from 329-1148 t, and for rock sole, 247-2409 t (Fig. 2). Fluctuations in the landings have largely been due to variable recruitment (Forrester and Thomson 1969, Stocker 1981, and Fargo 1985).

Predicting recruitment for these species is desirable for formulating management plans as well as indicating production trends for industry. Rivard (1983) discusses incorporation of a recruitment index from research data into a tuning phase of sequential population analysis for stock assessment.

Accordingly, a trawl survey of Hecate Strait was designed to provide absolute and relative indices of abundance primarily for juvenile English sole and rock sole. The first survey was completed in August 1980, and surveys have been conducted annually through 1985--August 1981, and April 1982-85. The change to April in 1982 was designed to avoid spiny dogfish (Squalus acanthias) which occupy the shallower portions of Hecate Strait during summer.

This report summarizes results of the first 6 annual juvenile flatfish trawl surveys conducted in Hecate Strait with regard to:

1. species composition.
2. size and age composition of important species.
3. results of experiments involving trawl-gear variations with respect to juvenile English and rock soles.
4. relative and absolute abundance indices for juvenile English and rock soles (ages 1 and 2) and absolute abundance for Pacific halibut (Hippoglossus stenolepis) (ages 2, 3, and 4).

MATERIALS

VESSELS

Chartered commercial trawlers were employed for the surveys. Four different vessels successfully competed for one or more charters. Their names and specifications are listed below:

Name	Year	Length(m)	Tonnage	Horsepower
Arctic Ocean	1981	21.34	93	425
Double Decker	1983,1984	19.81	87	350
Nucleus	1980,1982	18.90	87	365
Sunnfjord	1985	23.77	120	455

All charter-vessel captains had good production records from the Hecate Strait trawling grounds.

GEAR

The standard survey net, used in all surveys, was a Gulf, semi-ballon shrimp trawl with a 21.3-m (70-ft) headrope. Mesh size throughout was 3.8 cm (1.5 in), internal measure. The groundline was modified for rough bottom, and consisted of three sections of 5/8 x 6 x 24 cable. Each wing section was packed with 7.6-cm (3-in) rubber discs. The bosom section was packed with 15.2-cm (6-in) rubber discs. The groundline was fastened to the footrope with 25.4-cm (10-in) chain beckets.

Sweeplines, connecting each wing to the trawl, were 27.4 m (15 fath) long for the 1980-82 surveys; and 36.6 m (20 fath) for the 1983-85 surveys.

Trawl doors were provided by the charter vessel. In 1981, they were steel, rectangular, 2.7 x 1.2 m (9 x 4 ft). For 1982-84, they were wood, rectangular, 2.7 x 1.4 m (9 x 4.5 ft). In 1985, they were steel, v-shape, 3.2 x 2.1 m (10.5 x 6.9 ft).

USABLE HAULS

Usable hauls were defined as those: (1) whose catches were not affected by snags or gear malfunctions, such as crossed doors; (2) not completed in the wrong area or depth stratum; (3) not employing experimental gear (except small-mesh cod-end liner); or (4) not completed at night. Hauls in depth strata 0-9 fath and >59 fath were excluded, as well as those completed on grounds other than Moresby Bank[1] -- McIntyre Bay (west of Moresby Bank in Dixon Entrance) and the area east of Stephens Island (Fig. 1).

[1]Moresby Bank is named after the adjacent Moresby Gully (Westrheim 1974). Moresby Bank is bounded on the west by the Queen Charlotte Islands (to the northeast tip of Graham Island); on the north by Dixon Entrance; on the east by an unnamed gully (54°25' to 54°02' N lat); the B.C. mainland (54°02' to 53° 52' N lat); and Moresby Gully (53° 52' to 52°35' N lat); and on the south by Moresby Gully. Original name was Hecate Strait Bank (Ketchen 1956), at a time when the bathymetry of South Hecate Strait was poorly defined.

METHODS

SURVEY DESIGN

The 1980 survey employed a stratified-random design, as described in Stocker et al. 1981. Briefly, a grid of numbered squares of 5 minutes latitude by 5 minutes longitude was applied to the survey area in Hecate Strait and McIntyre Bay (W. Dixon Entrance). The area was further divided into four depth strata (0-9 fath, 10-19 fath, 20-49 fath, > 49 fath) based on data collected from juvenile flatfish surveys in Hecate Strait during 1952-54 (unpublished portion of Ketchen 1956). The total number of hauls to be completed on the survey was estimated and effort was allocated to the four depth strata according to expected occurrence of juvenile English sole and rock sole within each stratum. Individual stations to be occupied within strata were selected randomly.

The following modifications were made to the original survey design in chronological order:

1. Effort allocated to Dogfish Bank (0-9 fath) (Fig. 1) was re-allocated to other areas of the survey.
2. The timing of the survey was changed from August to April.
3. Distribution of effort for each year of the April survey was somewhat different depending on the distribution of juvenile flatfish encountered on each particular survey.

In 1981, the effort allocated to Dogfish Bank (0-9 fath) was reduced by 80%. Dogfish Bank was eliminated from the survey in subsequent years. There were two reasons for this:

1. The catch rates for juvenile rock sole and English sole on that Bank were much lower than anticipated and effort expended on the Bank during the 1980 survey was greater than effort expended in areas of higher densities for these juveniles elsewhere. Also high incidental catches of dogfish on the Bank interfered with sorting and sampling of juvenile flatfish.
2. The large variance among catch rates in 1980 indicated that too little effort was being expended in relation to the size of the area being surveyed. Excluding Dogfish Bank eliminated a significant amount of area from the survey.

In 1982, the timing of the survey was changed from August to April (Fargo et al. 1982). In 1980 and 1981, excessive catches of dogfish had interfered with assessment of juvenile flatfish abundance. Depths of the dogfish catches were coincidental with depths of peak abundance for juvenile flatfish (20-39 fath). Dogfish occupy deeper water (>50 fath) during the fall-spring months of the year while depth distribution of juvenile English and rock sole is fairly consistent year round.

Effort allocation for the April surveys was different to that for August surveys. Effort allocation on the August surveys was random with regard to several large areas (10-20 fath, 20-49 fath, >49 fath) for the survey. Catch rates from the 1980-81 surveys disclosed a number of aggregations of juvenile English sole and rock sole in Hecate Strait. The original set of random stations allocated to these areas of aggregation was retained. Stations allocated to areas of zero density for juvenile flatfish were dropped and additional effort was re-allocated to areas where aggregations of juvenile flatfish had been consistently encountered on previous surveys. The actual allocation of additional stations was a function of bottom type (trawlable bottom), and was proportional to density as determined by previous catch rates for these areas of aggregation.

Also, for each April survey, after each area of known aggregation of juvenile English and rock sole was trawled (~70% of the effort for the survey), additional effort (~30% of the survey) was allocated to areas of aggregation in proportion to the density of juvenile flatfish observed on the first stage of the survey. Comparative tows were attempted in as many areas as possible to measure precision of survey catch rates.

CATCH PROCESSING

When each trawl catch was brought aboard the vessel, one of two procedures was followed. If the total catch amounted to $\leq$ 1300 kg, the entire catch was sorted by species into plastic baskets (50 kg capacity) and each such basket weighed (to the nearest kilogram). Length frequencies (nearest cm FL) were collected from all English sole, rock sole and Pacific halibut. Other prominent species were processed if time permitted. If the catch was > 1300 kg, the entire catch was sorted by species into baskets for weighing, and length-frequencies for each important species were collected from a sample of the total catch, as per Westrheim (1967). The single exception was Pacific halibut. All halibut caught were measured for fork length and returned to the sea. Halibut weight was computed from a length-weight table provided by the International Pacific Halibut Commission.

Interopercle bones and/or otoliths were collected intermittently from English sole and rock sole for age determination studies ashore.

AGE COMPOSITION

Age composition was estimated only for the youngest two or three age-classes of juvenile specimens caught, based on length-frequency modes--ages 0-2 for English sole (0-1 in August; 1-2 in April); 1-2 for rock sole; 0-1 for Pacific cod; and 2-4 for Pacific halibut. Numbers of specimens assigned to an age-class were those in the appropriate modal length interval plus those in the two adjacent intervals. On the rare occasions (<5%) when no mode was evident, the "average" modal interval, from the same area-depth-time cell, was assigned.

Some verification of these age-class allocations was obtained from other publications, as follows:

Species	Source
English sole	Ketchen (1947)
Pacific cod	Ketchen (1964), Beamish et al. (1978)
Pacific halibut	Southward (1967)

For English sole and rock sole, further verification was obtained from readings of some of the otoliths collected during the 1980-82 surveys.

The only other method attempted was that of Schnute and Fournier (1980), which also analyzed length-frequencies. Unfortunately, results deviated significantly (Chi square) from results based on otolith readings.

EXPERIMENTAL HAULS

In each year, except 1984, some experimental hauls were completed. These dealt with either comparative hauls with standard trawl gear or variations in trawl gear. Comparative hauls took two forms--daylight versus daylight (1982-83, 85), and daylight versus dark (1981-83, 85). Variations in trawl gear compared the standard (shrimp) trawl: 1) with and without a small-mesh cod-end liner (1981, 1983); 2) with and without a small-mesh cod-end liner + tickler chain (1981); and 3) with a commercial (Skagen) groundfish trawl rigged for flatfish (1980).

Daylight comparative hauls were undertaken to investigate the variance of catch rates for selected species and selected age-classes. Daylight-night and trawl-gear comparisons were conducted primarily to investigate variations in availability.

Chi-square tests were employed to test the "independence" of paired catch rates of age-1 and age-2 English and rock soles as described in Yule and Kendall (1950, p. 474). Specifically,

$$\chi^2 = \frac{(O_1 - E)^2}{E} + \frac{(O_2 - E)^2}{E} = \frac{(4)(O_1 - E)^2}{(O_1 + O_2)}; \quad Df=1$$

where O_1 = CPUE of standard haul
O_2 = CPUE of experimental haul
$E = (O_1 + O_2)/2$

When replicate hauls were not available, results of the experimental haul were compared with the average results obtained from all standard hauls in the same area-depth cell in that same year.

RELATIVE YEAR-CLASS ABUNDANCE

Two indices were employed to estimate relative abundance--geometric mean CPUE (nos/h) and the square root of zero-catch incidence ($\sqrt{F_0}$). Geometric, rather than arithmetic, mean CPUE was selected, because of the highly skewed distributions of individual CPUEs, by species and age-class. $\sqrt{F_0}$ was selected, because the distributions of individual CPUEs generally followed a negative binomial distribution (mode = 0; $S_x^2 > \overline{X}$), and hence $\sqrt{F_0}$ was allegedly less biased than $\overline{CPUE}$ as an index of relative abundance (Bannerot and Austin 1983).

Geometric mean CPUEs. Computations were performed, by species and age-class, as follows:

$$\overline{CPUE} = \text{antilog}\left[\left(\sum_{i=1}^{n} \ln x_i\right)/(n_1 + n_0)\right]^n$$

where $\overline{CPUE}$ = geometric mean catch per unit effort (nos./h)
x_i = nos/h in haul i
n_1 = number of hauls in which nos/h > 0
n_0 = numbers of hauls in which nos/h = 0

The non-biased standard deviation of ln CPUE is computed in the conventional manner.

For each juvenile age-class of English sole and rock sole, viable hauls were initially segregated by sector (15' of latitude) and by depth interval (10 fath) to investigate spatial distribution of the juveniles, and appropriate CPUEs were computed. Regression of sector CPUEs on sector yielded poor correlations (R^2 = 0.011 to 0.13) for age-1 and age-2 English sole, and age-2 rock sole, but R^2 = 0.72 for age-1 rock sole. In contrast, regression of depth CPUEs on depth yielded good correlations (R^2 = 0.59 to 0.70) for age-1 and age-2 English sole, and age-1 rock sole, but poor ones (R^2 = 0.13) for age-2 rock sole.

Subsequent analyses were restricted to hauls completed on Moresby Bank which comprises most of the shallower portions of Hecate Strait (Fig. 1). Areas, by depth, in square nautical miles (sq M) are as follows:

Depth (fath)	Hecate Strait	Moresby Bank	% Moresby Bank
10-19	1333	1310	98.3
20-29	452	436	96.5
30-39	267	252	94.4
40-49	280	252	90.0
50-59	322	305	94.7
Total	2654	2555	96.3

Moresby Bank was divided into south and north sectors, at 53°30'N lat, which conform, for practical purposes, to groundfish statstical areas 5C and 5D, respectively. Area 5D also includes Dixon Entrance, but trawl catches of shelf species are minimal there.

For the English sole and rock sole analyses, the northernmost portion of Moresby Bank (>54°14'N lat) was excluded because few age-1 and age-2 specimens were caught there. Detailed records of CPUEs by area-depth cells, are contained in Appendix tables 7-8 for age-1 and age-2 English sole, and Appendix tables 9-10 for the same age-classes of rock sole.

English sole CPUEs were not available for age-0 fish in the April 1982-85 surveys (too small to be caught) and age-2 fish in the August 1980-81 surveys (length mode not clearly detectable). CPUEs for age-0 English sole were excluded from the analyses.

Zero-catch incidence. Computation of $\sqrt{F_0}$, by species, age-class, and depth interval is straightforward, and the results are in Appendix tables 11-12 for English sole and 13-14 for rock sole.

ABSOLUTE YEAR-CLASS ABUNDANCE

Biomass estimation

Absolute year-class abundance of English sole, rock sole, and Pacific halibut was estimated by the swept-area method. Computations were as follows:

$$\hat{N}_i = \sum_{j=1}^{n} (\overline{CPUE}_{ij})(A_j)(q) / (a)(K_i)$$

where $\hat{N}_i$ = estimated numbers of age-class i

$\overline{CPUE}_{ij}$ = geometric mean CPUE of age-class i in depth interval j, for English sole and rock sole.
= arithmetic mean CPUE of age-class i in depth interval j, for Pacific halibut

A_j = area (sq. M) of depth interval j

q = catchability coefficient (assumed to be 1)
a = area swept by the survey trawl in one hour
= (distance between wing tips) (distance trawled)
= 0.0123 sq. M

K_j = proportion of age-class included in modal separation of age-class
= 0.55

For Pacific halibut, usable hauls on Moresby Bank north of 54°14'N lat were included in the computations.

Results of computations are contained in Tables 29 and 30.

Confidence intervals

Confidence intervals were not calculated for absolute abundance estimates. One reason for this was the sampling scheme used for the April surveys. As stated earlier in the section on survey design, approximately 30% of the effort allocated on the April survey was a function of bottom type and previous catch rates in the survey. The sampling scheme was therefore not consistent with an initial hypothesis concerning the distribution of the species/age groups. In fact, that distribution changed from year to year. We felt that confidence limits calculated for our abundance estimates would not represent the true precision of the survey.

Leaman (1981) points out that survey estimates are nearly always used as point estimates regardless of their precision, and that increasing the precision of a survey may have little effect on the ultimate estimate of abundance.

GENERAL RESULTS

CRUISES

Six annual cruises have been completed to date -- two in August (1980-81) and four in April (1982-85). Results of each have been reported in the Data Reports cited in Table 1.

USABLE HAULS

Usable hauls employed in year-class assessment totalled 346 -- 148 on South Moresby Bank and 198 on North Moresby Bank (Table 2; Appendix tables 1-6). Few usable hauls were completed at 0-9 fath (5) or >59 fath (1). In 1984, adverse weather reduced the number of usable hauls to 31, compared to an average of 63 for the other five surveys.

Usable hauls excluded from year-class assessment totalled 23 (Table 3). Fifteen were excluded because they were not located on Moresby

Bank--14 in Dixon Entrance west of Moresby Bank, and one east of Stephens Island (Fig. 1). The other eight hauls were either completed at night (4), or employed experimental gear--Skagen commercial trawl (2) or cod-end liner + tickler chain (2). Usable hauls employing cod-end liners only were not excluded from year-class assessments.

SPECIES COMPOSITION

Principal target species in the trawl surveys were juvenile English sole and rock sole. Four additional species were important in the survey catches. These were Pacific cod (Gadus macrocephalus), Pacific halibut, skates (Rajidae, mostly Raja binoculata), and spiny dogfish.

During 1980-85, mean all-species catch rates were 705 kg/h on South Moresby Bank and 837 kg/h on North Moresby Bank (Table 4). Corresponding mean numbers of species caught were 19 (11-26) and 25 (23-30), respectively. The six "important" species comprised 88.2% of the all-species CPUE on South Moresby Bank and 77.4% on North Moresby Bank. Mean catch rates of English sole, Pacific cod, Pacific halibut, and skates were greater on North Moresby Bank (34-148 vs 10-63 kg/h); mean catch rates of spiny dogfish were substantially greater on South Moresby Bank (410 vs 223 kg/h); and catch rates of rock sole were slightly greater on South Moresby Bank (70 vs 64 kg/h).

COMMERCIAL PRODUCTION

Principal groundfish species harvested on the continental shelf of Hecate Strait are Pacific cod, rock sole, English sole, and Pacific halibut. The former three are trawl-caught, and during 1956-84 comprised some 66% of the all-species trawl landings[1] from Hecate Strait (Fig. 2). Pacific halibut are line-caught. Mean annual landings[2] during 1956-84 of these important species were as follows:

Species	Mean landings (t)	%
All; trawl-caught	8,434	100
Pacific cod	3,741	44.4
Rock sole	1,076	12.8
English sole	716	8.5
		67.5
Pacific halibut	2,735	

[1]Groundfish Data Series; Pacific Marine Fisheries Commission, Portland, OR.

[2]1956-75 (Myhre et al. 1977); 1976-84 (IPHC Annual Reports, 1976-84).

Area 5D produced 69% of the Pacific cod, 62% of the rock sole, 92% of the English sole (Fig. 2). Landings of Pacific halibut were not available by groundfish statistical area.

AGE COMPOSITION

During the six annual trawl surveys, fork-length measurements were recorded for 46,235 specimens, comprising 19 species (Table 5). Totals for the two primary target species were 20,656 English sole, and 17,089 rock sole. Useful data emerged for two additional species -- Pacific cod (2,715 specimens) and Pacific halibut (954 specimens).

English sole

Length-frequencies for August 1980-81 and April 1982-85 display distinct modes at 10-11 and 18 cm in August, and 11 and 19 cm in April (Table 6). For the August samples, the modes at 10-11 and 18 cm represent ages 0+ and 1+, while the April modes at 11 and 19 cm represent ages 1+ and 2+.

Rock sole

Length-frequencies for August 1980-81 and April 1982-85 display distinct modes at 10 and 15 cm in August, and 8 and 14 cm in April (Table 6). The modes at 8 and 10 cm reflect age 1+, while those at 14 and 15 cm reflect age 2+.

Pacific cod

Length-frequencies for August 1980-81 and April 1982-85 both display distinct modes at the 13-15 and 28-30 cm length intervals (Table 7). These modes reflect, respectively, ages 0+ and 1+, both of which are pre-recruit age-classes.

Pacific halibut

Length-frequencies for August 1980-81 display modes at the 30-34 and 50-54 cm length intervals (Table 7). The April 1982-85 array displays modes at the 25-29, 40-44, and 60-64 cm length intervals. The respective age-classes thus represented are 2+ (30-34 and 25-29 cm), 3+ (40-44 and 50-54 cm), and 4+ (60-64 cm). The absence of a mode for age-4 halibut in the August samples may have been due to a decrease in catchability for larger halibut of the shrimp trawl.

RESULTS OF SUB-EXPERIMENTS

COMPARATIVE DAYLIGHT HAULS

Five pairs of comparative daylight trawl hauls were completed -- one each in 1982 and 1983, and three in 1985. Four pairs were located on South Moresby Bank (Area 5C) and one pair on North Moresby Bank (Area 5D) (Table 8).

Length-frequency comparisons were feasible for two comparable pairs of English sole and three comparable pairs of rock sole.

English sole

Modal size of age-1 specimens could not be compared due to the absence in the catch of English sole < 14 cm in haul 13 of one pair, and < 16 cm in haul 38 of the other pair (Table 9). Modal size of age-2 English sole was 18 cm in both catches of the first replicate pair, but 18 and 19-20 cm in the second pair.

All-age catch rates of English sole were significantly different ($P<.01$) in both pairs -- 74.1 vs 176.6 fish/h; 83.3 vs 133.3 fish/h (Table 10). Catch rates of age-1 English sole were 0 in the first haul of each pair; 152.2 and 15.0 fish/h in the second haul of each pair. Catch rates of age-2 English sole were significantly different ($P<.01$) in each pair -- 190.6 vs 546.4 fish/h and 127.5 vs 327.5 fish/h. In all cases, catch rates were larger in the second haul of each pair.

Rock sole

Age-1 rock sole were absent from catches in five of the six hauls, and only minimally present in the other (Table 11). Age-2 rock sole were absent in the catches of two hauls -- one in each of two pairs. Modal lengths were 14 and 13 cm for the only testable pair of hauls. Modal sizes were 14 and 14-15 cm in the other two hauls, for which no comparable data were available.

All-age catch rates were significantly different ($P<.01$) in two of the three tests, and catch rate was higher in the second haul of both pairs (Table 11). Catch rate of age-1 rock sole was 2.1 fish/h in the only haul containing any. Catch rates of age-2 rock sole were significantly different ($P<.02$) in the single test, and here also, the catch rate was larger in the second haul.

Summary

Despite the limited data, heterogeneity is evident among comparable daylight hauls. Similarly the results for age-1 English sole and age-2 rock sole reflect drastic changes in catch rates of juveniles of these species.

The near-consistent larger catch rate for the second haul in each comparable pair suggests a time factor, such as tide, may be at work during the survey periods.

DAY AND NIGHT HAULS

Four night hauls were completed -- one each in 1981, 1982, 1983, and 1985 and all in 20-29 fath (Table 12). The 1981 haul was completed on North Moresby Bank, and the others on South Moresby Bank. Only the 1982 and 1985 night hauls had usable, comparative daylight hauls.

Length-frequency comparisons were completed for two "pairs" of English sole, and five "pairs" of rock sole.

English sole

Neither of the two tests involved a comparable pair. One "pair" was collected in 1982, and the other in 1983 (Table 13). Modal sizes at age 1+ were the same (13 cm) for the two length-frequencies in 1982, but larger in the night-haul catch (12 vs 11 cm) of 1983. Age-2 English sole were not definable by modal size.

All-age catch rates were heterogeneous in the 1982 test ($P<.01$) and homogeneous in the 1983 test ($P>.10$), and in both cases the day-haul catch rate was larger -- 312.0 vs 192.0 fish/h; 213.2 vs 185.4 (Table 14). Age-1 catch rates were homogeneous in both tests ($P>.20$, $>.05$). Day-haul catch rate was larger in 1982 (43.3 vs 34.0 fish/h), and smaller in 1983 (815 vs 1073).

Rock sole

Five sets of length-frequencies were tested -- one each in 1981, 1982, and 1983, and two (including a replicate pair) in 1985 (Table 14). Age-1 rock sole were present in 9 of the 10 length-frequencies. Modal sizes were larger for day hauls in August 1981 (11 cm vs 10 cm) and for comparative hauls in April 1982 (8 cm vs 7 cm); but equivalent in the remaining two tests (8 cm) (Table 15). Age-2 rock sole were present in all 10 hauls. Modal sizes were larger for day hauls in 1981 (16 cm vs 15 cm), 1982 (14 cm vs 13 cm), and in 1985 (16 cm vs 15 cm). In 1983, modal size of age-2 rock sole was larger in the night haul (15 cm vs 14 cm).

All-age catch rates were heterogeneous ($P<.01$) in four of the five tests. Catch rates were homogeneous ($P>.30$) in the 1985 test for south Moresby Bank. Night-haul catch rates were larger in the four heterogeneous pairs (98.3-2,116.2 vs 51.7-156.8 fish/h), but smaller in the homogeneous pair (98.3 vs 110.6). Age-1 catch rates were heterogeneous ($P<.01$) in three of the four tests. Catch rates were homogeneous ($P=0.50$) in one of the 1985 tests in Area 5C. Night-haul catch rates were larger in three of the four tests (1.6-475.3 vs 0.6-10.2 fish/h), including the homogeneous pair, and smaller in

one test (3.1 vs 23.0). Age-2 catch rates were heterogeneous (P<.01) in four of the five tests, and homogeneous (P>.50) in one (1985, 5C). Night-haul catches were larger in all four heterogeneous pairs, (129.3-708.3 vs 3.2-30.8 fish/h), but smaller in the single homogeneous pair (2.1 vs 3.2).

Summary

Night-haul catches of English sole were generally similar to day-haul catches with respect to modal size of age-1 fish (age-2 modes were not identifiable) and catch rates. Day-haul catch rates were generally larger for all-age and age-1 fish, but significantly so in only one of four tests.

Night-haul catches of rock sole generally differed from day-haul catches with respect to modal size and catch rate. Modal sizes of age-1 fish were generally similar, but for age-2 fish, day-haul modes were larger in four of five tests. Night-haul catch rates were larger for all-age (4/5), age-1 (4/5), and age-2 (3/4) fish, and significantly so in 10 of the 11 tests.

SMALL-MESH COD-END LINER

In August 1981, three hauls were completed using a trawl equipped with a small-mesh (19 mm) cod-end liner -- one on South Moresby Bank and two on North Moresby Bank (Table 16). Only one of the hauls had a usable, comparable haul, without a cod-end liner.

In April 1983, a second, unscheduled experiment was completed when a "spare" net was used intermittently which was equipped (unintentionally) with a small-mesh, cod-end liner. On South Moresby Bank, 29 usable hauls were completed, of which 10 were equipped with a small-mesh cod-end. On North Moresby Bank, all 27 usable hauls were completed with the trawl containing the small-mesh cod-end liner.

Length-frequency comparisons were feasible for three sets of English sole, and four sets of rock sole (Table 17). All of the English sole sets were from the 1983 collection. Rock sole sets were from the 1981 and 1983 collections.

English sole

Modal sizes of age-1 fish were larger in liner-equipped trawl catches at all three depth intervals -- 12 cm vs 11 cm at 20-29 fath, and 14 cm vs 13 cm at 40-49 and 50-59 fath (Table 18). Modal sizes of age-2 English sole were not definable, or absent, at 20-29 and 40-49 fath. At 50-59 fath, modal size was smaller, in the catch of the liner-trawl (18 cm vs 19 cm).

All-age catch rates were heterogeneous (P<.01) in each test, (Table 19). Catch rate for the liner-equipped trawl was larger at 20-29 fath and 50-59 fath but smaller at 40-49 fath. Catch rates for age-1 and age-2 English

sole were also heterogeneous (P<.01) in all cases. For age-1 fish, catch rate of the liner-equipped trawl was higher at 40-49 and 50-59 fath. For age-2 English sole, the catch rate for the liner-equipped trawl was larger at 40-49 fath and smaller at 20-29 and 50-59 fath.

Rock sole

Modal sizes of age-1 fish were the same (9-10 cm) for the 1981 set; and not definable, or absent, for the three sets in 1983 (Table 20). Modal sizes of age-2 rock sole were 14 cm at 20-29 fath and 13 cm at 40-49 fath -- both in 1983. For the remaining two sets, modal sizes of age-2 rock sole were doubtful or absent.

All-age catch rates were heterogeneous (P<.01) in three of the four tests (Table 19). Catch rates of the liner-equipped trawl were smaller in all four cases. Catch rates were all heterogeneous (P<.01) for both age-1 and age-2 rock sole. For each age-class, catch rate of the liner-equipped trawl was larger in half the tests.

Summary

Overall, the liner-equipped trawl appeared to be little better at catching English and rock soles than the trawl not so equipped. However, the liner-equipped trawl appears to be biased against age-1 English sole, although not for age-1 or age-2 rock sole. The limited data on age-2 English sole provide no clear evidence.

COD-END LINER AND TICKLER CHAIN

During the August 1981 survey, seven hauls were completed using a net equipped with both a small-mesh cod-end liner and a tickler chain (Table 21). Comparative hauls were successfully completed for five of these. All tests were conducted on North Moresby Bank, at depths of 10-19, 20-29, 40-49, and 50-59 fath.

Length-frequency comparisons were feasible for two sets of comparative hauls for English sole, and one set for rock sole (Table 22).

English sole

Few fish less than 19 cm, and none less than 15 cm, were caught in any of the five test hauls. Hence, catch rates could not be compared and/or determined for age-1 and age-2 English sole. All-age catch rates of the experimental net (cod-end liner + tickler) were significantly larger (P<.01) in all three tests (Table 23). Interestingly, catch rates of the comparative hauls to the experimental trawl were evidently significantly different (405.6 vs 88.8 fish/h).

Rock sole

Modal size of age-1 fish was larger in the catch of the experimental trawl (12 cm vs 11 cm). Modal sizes of age-2 rock sole were the same (17 cm) in the two trawls.

Catch rates of all-ages, age-1, and age-2 were significantly different ($P<.01$) between trawl types (Table 23). Catch rate of the experimental trawl was higher for all-ages and age 2+, but smaller for age 1+.

Summary

The experimental trawl (cod-end liner + tickler chain) outfished the standard trawl in 5 of the 6 tests, and the single exception was age-1 rock sole. Evidently, the tickler chain was the important contributing factor, since the liner-equipped trawl (without tickler chain) did not consistently outperform the standard survey trawl. Walsh (1984) reported that addition of a tickler chain increased the shrimp trawl (Yankee No. 36 design) catches of juvenile (≤ 30 cm) witch flounder (Glyptocephalus cynoglossus) and American plaice (Hippoglossoides platessoides), but not Greenland halibut (Reinhardtius hippoglossoides), in the Gulf of St. Lawrence.

SURVEY TRAWL VERSUS COMMERCIAL TRAWL

In August 1980, the standard shrimp trawl was tested against a commercial (Skagen) groundfish trawl rigged for flatfish. Two pairs of test hauls were completed (Table 24).

Length-frequency comparisons were feasible for one set of English sole, and both sets of rock sole (Table 25).

English sole

No fish smaller than 14 cm were caught in either trawl, and hence few if any age-0 English sole were caught (Table 25). Modal size of age-1 English sole was 17 cm in the survey-trawl catch, and probably 19 cm in the commercial-trawl catch.

All-age catch rate was significantly larger ($P<.01$) for the survey trawl (424.2 vs 197.0 fish/h), and for age-1 English sole (239.5 vs 21.2 fish/h) (Table 26). Evidently, the commercial trawl did not sample the juvenile English sole well in this test.

Rock sole

All-age catch rates were significantly different ($P<.01$) in both tests (Table 25). The survey-trawl catch rate was higher in the first comparison (484.8 vs 384.8 fish/h) and smaller in the second comparison (84.0

vs 488.0 fish/h). Age-1 specimens were absent from both commercial-trawl catches, and age-2 specimens were absent from one commercial-trawl catch (Table 25). Perversely, age-2 rock sole were absent, or poorly represented, in the survey-trawl catch matched with the commercial-trawl catch containing age-2 specimens. Significantly, one survey-trawl haul (No. 1) contained substantial numbers of age-1 (36.4 fish/h) and age-2 (75.7 fish/h) rock sole, while the comparative commercial trawl haul (No. 2) contained none of either age-class.

Summary

The Skagen (commercial) trawl was evidently biased against age-0 and age-1 English sole, as well as age-1 and age-2 rock sole, in the limited tests conducted. Similar results were reported by Walsh (1984) for witch flounder and American plaice in the Gulf of St. Lawrence. All-age catch rates of our shrimp trawl exceeded those of the Skagen trawl in two of the three tests conducted.

SUMMARY

Most experiments involved too few comparable hauls to justify any firm conclusions. However some interesting results appeared which possibly warrant further study.

The five comparable pairs of daylight hauls revealed a substantial heterogeneity in catch rates of age-1 and-2 English sole and rock sole.

For the four tests of night-haul versus day-hauls, night-haul catch rates were consistently higher for age-1 and age-2 rock sole, but not so for age-1 and age-2 English sole.

The six tests of trawls with a small-mesh cod-end liner indicated no consistent advantage for either standard or experimental gear with respect to age-1 and -2 English sole or rock sole. The liner-equipped trawl appeared to be biased against the smaller age-1 English sole.

The five tests of the trawl equipped with a small-mesh cod-end liner and tickler chain indicated juvenile English sole were virtually absent in the experimental trawl (this may have been due to factors other than gear), and mixed results were obtained for age-1 and -2 rock sole.

The two tests of a commercial trawl indicated the survey trawl was more effective in catching juvenile English and rock sole.

RELATIVE YEAR-CLASS ABUNDANCE

The two indices of relative abundance ($\overline{CPUE}$; $\sqrt{F_0}$) yielded mixed results for English and rock soles, both within and among indices. Pacific cod and Pacific halibut were not included in this analysis due to insufficient data.

Within indices (among year-classes) of English sole and rock sole abundance, relationships were weak--R^2=0.00-0.31 (Table 27). Only one regression was negative, that of $\overline{CPUE}$s for rock sole (R^2=0.19).

Among indices (within age-classes) of English sole and rock sole abundance, all four regressions ($\overline{CPUE}$ on $\sqrt{F_0}$) were negative, as expected (Table 28). R^2 values were relatively large for age-1 English sole and age-2 rock sole (0.60), and relatively small for age-2 English sole (0.29) and age-1 rock sole (0.32).

In summary, neither abundance index produced consistent results within year-classes (age-1 versus age-2) for either English sole or rock sole, nor were the two indices well correlated (within age-classes) with one another.

Generally heterogeneous relationships of abundance indices among and within year-classes led to multiple apparent trends in year-class abundance of English sole and rock sole.

For English sole, $\overline{CPUE}$ values for age-1 fish (year-classes 1980-83) ranged from 3.21 to 11.3 fish/h, and exhibited a more or less steady rising trend (Table 27). For age-2 fish, $\overline{CPUE}$ values ranged from 8.38 to 30.8 fish/h, with a slight, but irregular, rising trend. $\overline{\sqrt{F_0}}$ values for age-1 fish ranged from 0.66 to 0.85, and exhibited a steady downward trend (= rising abundance). Corresponding values for age-2 fish ranged from 0.75 to 0.84, and exhibited a slight downward trend (= rising abundance).

For rock sole, $\overline{CPUE}$ values for age-1 fish (1979-83 year-classes) ranged from 1.30 to 5.17 fish/h, and exhibited a steady decline (Table 27). Corresponding values for age-2 fish were 2.65-9.40 fish/h, and exhibited a dome-shape relationship--peak at the 1983 year-class. $\sqrt{F_0}$ values for age-1 rock sole ranged from 0.77 to 0.84, and exhibited steady rising trend (= declining abundance) for year-classes 1980-83. Comparable values for age-2 fish ranged from 0.44 to 0.79, and exhibited a steady decline (= rising abundance) for year-classes 1979-82.

ABSOLUTE ABUNDANCE

Absolute abundance (1000s of fish) was calculated for age-1 and age-2 English sole (1979-84 year-classes) and rock sole (1978-84 year-classes), and age-2, -3, and -4 Pacific halibut (1977-83 year-classes).

English sole

Estimated absolute abundance of age-1 English sole on Moresby Bank (south of 54°15'N lat) ranged from 428,000 (1980 year-class) to 2,855,000 (1984 year-class) individuals at 10-59 fath (Table 29). Comparable values for age-2 English sole were 278,000 (1980 year-class) to 2,247,000 (1984 year-class). No estimates were possible for age-2 fish from year-classes 1980, 1981, and 1984. Curiously, North Moresby Bank contained only 34.1% of the age-1 English sole, and 20.8% of the age-2 fish despite the fact that some 90% of the commercial landings originate from there. Abundance was probably underestimated for age-1 fish, of the 1982 year-class, on North Moresby Bank, because the trawl net contained a small-mesh cod-end liner for all usable hauls (see Table 18).

Rock sole

Estimated absolute abundance of age-1 rock sole on Moresby Bank (south of 54°15'N lat), at 10-49 fath, ranged from 176,000 (1984 year-class) to 739,000 (1979 year-class) individuals -- 57.4% from North Moresby Bank for year-classes 1979-84 (Table 29). Comparable values for age-2 rock sole were 341,000 (1979 year-class) to 2,014,000 (1978 year-class) individuals -- 49.5% on North Moresby Bank for year-classes 1978-83. No estimates were possible for age-1 fish of the 1978 year-class or age-2 fish of the 1984 year-class. Abundance may have been underestimated for age-1 rock sole, of the 1982 year-class, on North Moresby Bank due to the evident bias against age-1 rock sole by the trawl when equipped with a small-mesh cod-end (see Table 20).

Pacific halibut

Excluding the anomalous results of the 1983 survey, biomass estimates for age-classes 2-4 ranged from 14,000 fish (age-2; 1983 year-class) to 1,281,000 fish (age-3; 1978 year-class) (Table 30). The 1978 year-class appears to be the most abundant at ages 2 (420,000 fish), 3 (1,218,000), and 4 (1,213,000). Based on age-class 3, year-class 1982 (vs 1980) is the least abundant.

North Moresby Bank contained most of the juvenile halibut, despite the greater area at 10-39 fath (where most of the juveniles are caught; Appendix table 15) on South Moresby Bank -- 1,139 vs 859 sq M.

Three insights emerge from these data. First, the 1978 year-class is large with respect to those of 1977-83. Second, abundance may be measurable, at least relatively, at age-3 and age-4, but not at age-2. Third,

juvenile halibut appear to be dispersing southward on Moresby Bank from age-2 to age-4. The southerly dispersion is particularly evident for the 1978 year-class -- 25.8% on South Moresby Bank at age 2, 32.9% at age 3, and 45.5% at age 4.

DISCUSSION

Four groundfish species appear to be vulnerable to the current trawl survey with respect to predicting year-class abundance based on relative or absolute abundance of pre-recruit age-classes. These are English sole, rock sole, Pacific halibut, and Pacific cod. Pacific cod, however, is considered tentative because of its extreme low abundance during the 1980-85 survey period. However, this species is noted for substantial fluctuations in abundance (Westrheim and Foucher 1985), and we are reasonably confident that subsequent trawl surveys would detect future increases in cod abundance, as well as provide much-needed information on distribution of juvenile cod in Hecate Strait.

None of the experimental-haul analyses involved sufficient numbers of hauls to justify any firm conclusions. However, it was heartening to note that adequate studies elsewhere corroborated our meager results with respect to cod-end liner + tickler chain, and commercial groundfish trawl versus survey shrimp trawl. Daylight comparative hauls demonstrated the substantial variability to be expected in CPUEs, and provided ample warning with respect to the "accuracy" of subsequent estimates of relative or absolute year-class abundance.

Comparison of abundance indices for species/year-classes from different surveys is complicated by the changes in survey design that have taken place during 1980-85. The most obvious difference is that between the August and April surveys. If the August surveys are disregarded for the purpose of correlating year-class abundance indices over time, correlations improve somewhat, but the trends in year-class strengths for English and rock soles remain the same.

In order to use the abundance indices for fine-tuning virtual population analyses for English and rock soles, the precision of these data sets would have to be about the same as that for data sets used to estimate catch-at-age from the commercial fishery. In fact, the precision of the survey data sets is substantially lower. It is unlikely, then, that the survey data sets could be used for any elaborate sequential population analyses.

The survey data sets could be useful as indicators of the relative trends of future recruitment for English sole, Pacific halibut, and rock sole in Hecate Strait. Empirical tests of year-class abundance estimates will soon be underway as the 1978-84 year-classes of these species recruit to the commercial fisheries in Hecate Strait.

Results of the surveys regarding the distribution of juvenile English and rock soles may help in assessing how the commercial fishery in Hecate Strait impacts partially recruited year-classes. Of special interest is the near-uniform distribution of age-1 and age-2 English sole throughout Moresby Bank, although some 90% of the English sole commercial production originates on North Moresby Bank. Ketchen (1956) described the distribution of age-1 and age-2 English sole in Hecate Strait during his 1952-54 surveys. That distribution was similar to our results with regard to area. Currently, we suspect that most of the juveniles on South Moresby Bank ultimately recruit to the adult stock inhabiting North Moresby Bank during spring and summer. Such a recruitment pattern might help to explain the ability of the English sole stock on North Moresby Bank to withstand the relatively heavy trawl effort expended in the late 1970s (Fargo 1985). Rock sole has not been so successful, perhaps because the rock sole juveniles recruit to fisheries coincidental with their "nursery" areas -- only some 62% of the rock sole landings originate on North Moresby Bank.

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Table 1. Inventory of reports of research vessel cruises completed to survey juvenile flatfish in Hecate Strait, 1980-85.

Year	Date	Reference
1980	August 11-25	Stocker et al. (1981)
1981	August 6-21	Fargo, Hoyt, and Robinson (1982)
1982	April 1-18	Fargo, Harling, et al. (1982)
1983	April 12-29	Fargo, Cooper, et al. (1983)
1984	April 10-27	Fargo, Foucher, et al. (1984)
1985	April 9-26	Fargo, Selsby, et al. (1985)

Table 2. Numbers of usable trawl hauls completed, by 10-fath depth interval, on Moresby Bank, 1980-85.

Year	Area	Depth interval (fath) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	Total
1980	South	-	9	5	6	3	-	-	23
	North	5	21	10	2	5	1	-	44
	Total	5	30	15	8	8	1	-	67
1981	South	-	6	6	6	1	1	-	20
	North	-	19	10	4	4	3	1	41
	Total	-	25	16	10	5	4	1	61
1982	South	-	8	10	6	5	2	-	31
	North	-	11	11	8	1	1	-	32
	Total	-	19	21	14	6	3	-	63
1983	South	-	6	9	5	5	3	-	28
	North	-	9	9	5	4	2	-	29
	Total	-	15	18	10	9	5	-	57
1984	South	-	5	6	5	-	-	-	16
	North	-	6	6	-	2	1	-	15
	Total	-	11	12	5	2	1	-	31
1985	South	-	5	13	5	2	5	-	30
	North	-	10	11	7	7	2	-	37
	Total	-	15	24	12	9	7	-	67
Sub-total	South	-	39	49	33	16	11	-	148
%		-	26.4	33.1	22.3	10.8	7.4	-	100.0
Sub-total	North	5	76	57	26	23	10	1	198
%		2.5	38.4	28.8	12.6	12.1	5.1	0.5	100.0
Total	N & S	5	115	106	59	39	21	1	346
%		1.4	33.2	30.6	16.8	11.6	6.1	0.3	100.0

Table 3. Inventory of usable hauls omitted from analyses of year-class abundance.

Year	Haul	Area	Depth (fath)	Remarks
1980	2	5D	10	Skagen trawl.
	43	5D	10	Skagen trawl.
	82-85	5D	10-50	McIntyre Bay (west of Moresby Bank).
	86	5D	30	Stephens Island (east of Moresby Bank).
1981	22	5D	50	Cod-end liner + tickler chain.
	42	5D	20	Cod-end liner + tickler chain.
	44	5D	60	Too deep.
	66-74	5D	0-50	McIntyre Bay (west of Moresby Bank).
	76	5D	20	Zero catch (25 min).
	78	5D	10	Night haul.
	80	5D	10	Stephens Island (east of Moresby Bank).
1982	64	5C	10	Night haul.
1983	57	5C	20	Night haul.
1985	68	5C	20	Night haul.

Table 4. Catch rates (kg/h), by area and year, of selected species caught during the annual trawl surveys of juvenile flatfish on Moresby Bank, 1980-85.

Species	1980 Aug.	1981 Aug.	1982 Apr.	1983 Apr.	1984 Apr.	1985 Apr.	Mean	%
				South				
All	183.5	70.8	23.3	39.9	51.9	53.7	70.5	
(Nos. of spp.)	(23)	(11)	(26)	(23)	(16)	(15)	(19)	
English sole	4.9	12.0	5.8	8.1	5.6	1.2	6.3	8.9
Rock sole	7.9	1.9	3.9	8.8	15.2	4.0	7.0	9.9
Pacific cod	2.4	0.5	1.3	1.4	0.1	0.2	1.0	1.4
Pacific halibut	4.2	1.9	1.2	2.3	1.3	1.1	2.0	2.8
Skates	6.5	0.1	5.6	6.3	14.8	1.3	4.9	7.0
Spiny dogfish	147.8	52.8	0.2	T	6.6	38.7	41.0	58.2
								88.2
				North				
All	118.4	69.2	61.2	112.5	92.6	48.2	83.7	
(Nos. of spp.)	(30)	(25)	(23)	(21)[a]	(24)	(29)	(25+)	
English sole	6.0	6.4	22.1	5.4	17.0	4.1	10.2	12.2
Rock sole	6.9	1.7	6.4	6.4	11.7	5.0	6.4	7.6
Pacific cod	6.1	1.8	10.1	64.4	34.5	3.1	14.8	17.7
Pacific halibut	3.0	5.0	3.7	1.2	4.9	2.6	3.4	4.1
Skates	3.2	0.2	2.2	15.8	18.9	5.8	7.7	9.2
Spiny dogfish	68.1	41.2	8.3	0.5	0.5	15.4	22.3	26.6
								77.4

[a]Minimum estimate. "Misc. spp." reported in some hauls.

Table 5. Numbers of specimens measured fork length (cm), by species and year, during the annual trawl surveys of juvenile flatfish in Hecate Strait, 1980-85.

Species	1980	1981	1982	1983	1984	1985	Total
Arrowtooth flounder	92	-	-	-	-	-	92
Butter sole	-	-	333	445	301	-	1,079
Dover sole	401	91	149	13	266	-	920
English sole	5,328	5,359	3,471	4,128	2,370	5,686	20,656
Pacific halibut	160	359	285	42	96	119	954
Pacific sanddab	-	-	-	173	-	-	173
Petrale sole	12	15	-	-	-	-	27
Rock sole	3,542	1,958	3,929	4,791	2,869	4,276	17,089
Sand sole	-	-	215	163	14	-	392
Yellowfish sole	-	3	-	-	-	-	3
Lingcod	9	2	-	-	-	-	11
Pacific cod	1,251	126	746	500	92	-	2,715
Pacific herring	-	-	148	-	-	-	148
Sablefish	-	-	99	-	-	-	99
Sandlance	-	-	551	-	43	-	594
Walleye pollock	86	33	408	301	-	-	828
Sebastes flavidus	-	-	68	-	-	-	68
S. wilsoni	80	-	-	-	-	-	80
Spiny dogfish[a]	404	-	201	-	-	-	605
Total	11,205	7,956	10,605	10,514	5,955	10,081	46,235

[a]Total length, with dorsal lobe of tail in line with body.

Table 6. Length frequencies (0/00), for English sole and rock sole, ≤30 cm, caught in the annual trawl surveys of juvenile flatfish in Hecate Strait 1980-85.

Fork Length (cm)	English sole		Rock sole	
	Aug 80-81	Apr 82-85	Aug 80-81	Apr 82-85
4	-	-	-	-
5	-	-	-	1
6	-	-	-	5
7	-	-	1	13
8	3	2	8	22
9	10	21	41	14
10	13	96	78	7
1	12	128	59	14
2	6	101	36	29
3	5	73	28	39
4	8	52	51	43
15	24	41	76	37
6	44	29	57	31
7	54	25	46	41
8	59	33	42	59
9	55	37	37	67
20	62	31	54	72
1	64	32	50	71
2	73	36	47	98
3	71	32	48	74
4	75	31	49	50
25	75	33	38	52
6	67	27	44	49
7	64	32	33	32
8	62	30	27	28
9	48	37	21	25
30	46	42	30	27
Total	1,000	1,001	1,001	1,000
Na	(13,345)	(36,236)	(3,774)	(13,225)

[a]Nos. caught

Table 7. Length-frequencies (0/00) of Pacific cod and Pacific halibut caught during the annual trawl surveys for juvenile flatfish in Hecate Strait, 1980-85. (Computed from the respective cumulative catch rates.)

Fork Length[a] (cm)	Pacific cod		Fork Length[b] (cm)	Pacific halibut	
	Aug 1980-81	Apr 1982-85		Aug 1980-81	Apr 1982-85
11	3	1	12	2	-
14	22	7	17	0	4
17	7	4	22	4	12
20	15	30	27	38	16
23	81	45	32	48	8
26	134	136	37	17	37
29	266	157	42	48	122
32	214	97	47	129	81
35	136	44	52	133	102
38	45	24	57	131	122
41	18	25	62	100	131
44	9	21	67	91	106
47	8	35	72	77	73
50	9	34	77	52	53
53	4	41	82	44	41
56	7	45	87	27	28
59	6	71	92	13	16
62	5	73	97	12	8
65	3	52	102	8	12
68	1	27	107	2	4
71	3	19	112	4	12
74	T	8	117	6	T
77	3	3	122	4	12
80	1	1	127	4	T
83	T	-	132	2	-
86	T	-	137	2	-
			142	2	-
Total	1,000	1,000	Total	1,000	1,000

[a]3-cm intervals: 11 = 10-12 cm; etc.
[b]5-cm intervals: 12 = 10-14 cm; etc.

Table 8. Inventory of comparable daylight hauls, and length measurements of selected species, by area and year, on Moresby Bank, April 1982-83 and 1985.

Year	Haul no.	Date (Apr)	Time (PST)	Dur. (min.)	Depth (fath)	Nos. measured			
						English	Rock	Cod	Halibut
					South				
1982	17	4	1730	28	19-18	-	23	-	-
	62	14	1419	29	20	-	69	-	5
1983	9	15	1319	31	27	6	46	-	3
	56	25	1348	24	26	267[a]	252[a]	-	-
1985	12	13	1621	25	34-35	-	-	-	-
	52	19	1348	27	35-36	23	53	-	1
	13	13	1751	17	50-49	35[b]	3[b]	-	-
	51	19	1240	28	51	824	-	-	3
					North				
1985	38	17	1707	24	39	179[c]	18	-	-
	55	21	1633	24	37-35	533	309	-	2

[a] L-F only for specimens ≤ 20cm.

[b] Sample.

[c] L-F only for specimens ≤ 30cm.

Table 9. Length-frequencies (nos./h), by area, of English sole caught in comparative daylight hauls on Moresby Bank April 1985.

Fork Length	South		North	
(cm)	13	51	38	55
9	-	4.3	-	-
10	-	42.9	-	-
11	-	79.3	-	12.5
12	-	30.0	-	2.5
13	-	32.1	-	10.0
14	63.5	32.1	-	15.0
15	63.5	96.4	-	22.5
16	63.5	154.3	17.5	25.0
17	0	173.6	35.0	65.0
18	127.1	205.7	50.0	97.5
19	63.5	167.1	42.5	115.0[a]
20	63.5	113.6	20.0	115.0
21	63.5	120.0	35.0	105.0
22	63.5	72.9	90.0	135.0
23	84.7	49.3	82.5	85.0
24	0	32.1	110.0	112.5
25	63.5	27.9	77.5	82.5
>25	21.4	382.1	302.5	332.5
Total	741.2	1765.7	832.5	1332.5
Age 1+	-	152.2	-	15.0
Age 2+	190.6	546.4	127.5	327.5

[a]Arbitrary "mode".

Table 10. Chi-square tests of catch rates (nos./h), by area and year, of selected age-classes of English sole and rock sole caught in comparative daylight hauls on Moresby Bank, April 1982-83 and 1985.

Area[a]	Year	Haul no.	Age (y)	Catch rate nos./h (x)	Catch rate nos./h (y)	x^2[b]	P
			English sole				
S	1985	13	All	741.2	1765.7	419	<.01
			2+	190.6	546.4	172	<.01
N	1985	38	All	832.5	1332.5	115	<.01
			2+	127.5	327.5	88	<.01
			Rock sole				
S	1982	17	All	49.3	142.8	46	<.01
	1983	9	All	89.0	87.5	0.013	>.80
			2+	3.9	15.0	6.519	<.02
	1985	38	All	45.0	772.5	647	<.01

[a] N=North Moresby Bank; S=South Moresby Bank.

[b] $\chi^2=4\ [x-(x+y)/2]^2/(x+y)$; Df=1.

Table 11. Length-frequencies (nos./h), by year and area, of rock sole caught in comparative daylight hauls on South Moresby Bank, April 1982-83 and 1985.

Fork Length	1982		1983		1985	
(cm)	17	62	9	56	38	55
7	-	2.1	-	-	-	-
8	-	0	-	-	-	-
9	-	0	-	-	-	-
10	-	0	-	-	-	-
11	-	0	-	-	-	-
12	-	0	-	2.5	-	-
13	-	2.1	-	7.5	-	-
14	-	8.3	3.9	5.0	-	2.5
15	-	0	0	2.5	-	2.5
16	-	0	0	0	-	0
17	-	0	1.9	0	-	12.5
18	-	0	1.9	10.0	-	62.5
19	-	2.1	1.9	0	-	82.5
20	-	-	5.8	2.5	5.0	115.0
>20	49.3	128.2	73.6	57.5	40.0	495.0
Total	49.3	142.8	89.0	87.5	45.0	772.5
Age 1+	-	2.1	-	-	-	-
Age 2+	-	10.4	3.9	15.0	-	5.0

Table 12. Inventory, by area and year, of hauls completed, and numbers of length measurements collected from selected species, by night (N) and day (D), on Moresby Bank, August 1981 and April 1982 and 1985.

Year	Haul no.	D/N	Date[a]	Time[b]	Dur. (min.)	Depth (fath.)	Nos. measured			
							English	Rock	Cod	Halibut
					South					
1982	62	D	14	1419	29	20	2	69	-	5
	64	N	14	2030	30	18-20	96	443	-	3
1983	57	N	25	2053	22	26	254	783	-	-
1985	70	D	24	0902	25	20-22	-	124	-	-
	68	N	24	0032	25	21-20	-	236	-	-
					North					
1981	78	N	20	0001	31	19-20	14	365	-	10

[a]August for 1981; April 1982-85.

[b]PST for April; PDT for August.

Table 13. Length-frequencies (nos./h), by year, of English sole caught in night (N) and day (D) hauls completed on South Moresby Bank, April 1982-83.

Fork Length (cm)	Haul no:	1982 All D	1982 64 N	1983 All D	1983 57 N
8		-	-	0.2	-
9		1.6	-	1.7	-
10		3.3	-	13.4	3.6
11		7.5	4.0	35.9	27.0
12		11.5	10.0	32.2	43.1
13		16.6	14.0	18.5	37.2
14		15.2	10.0	3.2	19.7
15		9.1	2.0	.7	8.8
16		3.5	2.0	0	5.1
17		0.7	0	0	0.7
18		2.3	0	.5	4.4
19		2.3	0	0	5.8
20		4.5	0	.2	8.8
21		7.0	0	0	0.7
22		5.2	0	0	2.9
23		6.8	0	0	3.6
24		8.4	0	0	5.1
25		10.8	0	0	3.6
26		13.1	0	0	0
27		13.1	0	0	1.5
28		15.9	2.0	0	0
29		16.9	0	0	0.7
30		10.8	0.7	.7	
>30					
Total		312.0	192.0	213.2	185.4
Age 1+		43.3	34.0	81.5	107.3
Age 2+[a]		-	-	-	-

[a]No length mode discernible for age-2 English sole

Table 14. Chi-square tests of catch rates (nos./h), by area and year, for selected age-classes of English sole and rock sole caught in night (N) and day (D) hauls on Moresby Bank, August 1981 and April 1982-83, 1985.

Area[a]	Year	Haul no. D	Haul no. N	Age (y)	Catch rate[a] (Nos./h) D	Catch rate[a] (Nos./h) N	χ^2 [b]	P
				English sole				
S	1982	All	64	All	312.0	192.0	29	<.01
				1+	43.3	34.0	1.119	>.20
	1983	All	57	All	213.2	185.4	1.939	>.10
				1+	81.5	107.3	3.526	>.05
				Rock sole				
S	1982	62	64	All	142.8	886.0	537	<.01
				1+	2.1	344.0	338	<.01
				2+	10.4	150.0	121	<.01
	1983	All	57	All	156.8	2,116.2	1,698	<.01
				1+	23.0	3.1	15	<.01
				2+	30.8	708.2	621	<.01
	1985	70	68	All	51.7	98.3	14	<.01
		All	68	All	110.6	98.3	0.724	>.30
				2+	3.2	129.3	115	<.01
N	1981	All	78	All	76.4	842.3	639	<.01
				1+	10.2	475.3	446	<.01
				2+	4.9	129.3	115	<.01

[a] N=North Moresby Bank; S=South Moresby Bank.

[b] $\chi^2=4[D-(D+N)/2]^2/(D+N)$; Df=1.

Table 15. Length-frequencies (nos./h), by year and area, of rock sole caught at 20-29 fath in night (N) and day (D) hauls completed on Moresby Bank, August 1981 and April 1982-83 and 1985.

Fork	1981 (N)[a]		1982 (S)[a]			1983 (S)[a]		1985 (S)[a]		
Length (cm)	All D	78 N	All D	64 N	62 D	All D	57 N	All D	68 N	70 D
4	-	-	-	2.0	-	-	-	0.2	-	-
5	-	2.3	-	2.0	-	-	-	0	-	-
6	-	0	3.8	20.0	-	0.5	-	0	-	-
7	-	2.3	10.3	96.0	2.1	3.7	0.4	0	-	-
8	-	34.6	10.5	166.0	0	10.5	2.7	0.4	0.8	-
9	1.6	159.2	3.3	82.0	0	8.8	0	0.2	0.8	-
10	2.5	223.8	.7	26.0	0	2.9	0	0.2	0.4	-
11	4.2	92.3	4.2	24.0	0	5.1	2.7	0.2	0	-
12	3.5	13.8	3.0	40.0	0	7.6	16.2	1.6	1.7	-
13	1.6	2.3	3.0	64.0	2.1	8.3	54.1	1.4	0.8	-
14	.9	27.7	4.5	46.0	8.3	12.7	186.5	1.0	5.4	-
15	1.4	50.8[b]	1.6	46.0	0	9.8	275.7	1.0	6.7	-
16	1.9	50.8	1.2	18.0	0	3.9	246.0	1.4	3.8	1.3
17	1.6	25.4	0	8.0	0	4.4	151.4	0.8	3.3	0.8
18	1.9	20.8	0.7	6.0	0	1.5	121.6	0.8	0.8	0.8
19	1.4	4.6	1.2	0	2.1	0.7	146.0	0.2	1.3	0
20	3.5	20.8	0.2	0	0	2.0	175.7	0.2	1.7	0.2
21	1.6	9.2	0.7	2.0	0	1.0	154.1	0.2	1.7	0
22	1.4	6.9	1.6	2.0	0	1.0	91.9	0.8	1.3	0
23	1.9	20.8	0	2.0	0	0.2	56.8	0.8	1.7	0
24	1.6	16.2	0	0	0	0.2	43.3	0.8	0.4	0
25	1.2	13.8	0.5	-	-	1.5	35.1	1.4	1.7	0.8
>25	42.7	43.9	56.3	234.0	128.2	70.5	356.0	96.0	64.0	47.8
Total	76.4	842.3	107.3	886.0	142.8	156.8	2116.2	110.6	98.3	51.7
Age 1+	10.2	475.3	24.1	344.0	2.1	23.0	3.1	0.6	1.6	-
Age 2+	4.9	129.3	9.3	150.0	10.4	30.8	718.2	3.2	15.9	2.1

[a]N=North Moresby Bank; S=South Moresby Bank.

[b]Arbitrary mode.

Table 16. Inventory, by year, area, and depth, of individual hauls completed, with (Y) and without (N) a small-mesh cod-end liner, on Moresby Bank, August 1981 and April 1983.

Year	Area[a]	Depth[b] interval (fath)	Liner	Haul nos.						Total
1981	S	30	N	7	-	-	-	-	-	1
			Y	8	-	-	-	-	-	1
	N	10	Y	25	-	-	-	-	-	1
		40	Y	80	-	-	-	-	-	1
1983	S	10	N	10	63	-	-	-	-	2
			Y	11	49	51	52	-	-	4
		20	N	2	3	9	12	55	56	6
			Y	15	16	50	53	-	-	4
		30	All usable hauls completed <u>without</u> a cod-end liner.							5
		40	N	1	5	14	59	-	-	4
			Y	18	-	-	-	-	-	1
		50	N	6	61	-	-	-	-	2
			Y	48	-	-	-	-	-	1
1983	N	All usable hauls completed <u>with</u> a cod-end liner.								28

[a]N=North Moresby Bank; S=South Moresby Bank

[b]10=10-19; etc.

Table 17. Inventory of length-frequencies (nos. measured), by area, year, and depth, of selected species caught by trawls with (Y) and without (N) a small-mesh cod-end liner on Moresby Bank, August 1981 and April 1983.

Year	Depth internal (fath)	Liner	No. of hauls	Numbers measured			
				English	Rock	Cod	Halibut
			South				
1981	30	N	1	-	87	-	10
		Y	1	-	84	-	14
1983	10	N	2	-	106	-	1
		Y	4	-	182	15	6
	20	N	6	268	465	108	3
		Y	4	177	213	-	1
	40	N	4	584	199	-	2
		Y	1	320	43	-	-
	50	N	3	71	11	-	-
		Y	1	531	-	-	-
			North				
1981	10	Y	1	1	6	-	-
	40	Y	1	26[a]	-	-	-

[a]Total catch includes 2 specimens <30 cm -- 16 & 29 cm.

Table 18. Length-frequencies (nos./h), by depth, of English sole caught by trawls with (Y) and without (N) a small-mesh cod-end liner, on South Moresby Bank, April 1983.

Fork Length (cm)	Depth (fath) 20-29		40-49		50-59	
	N	Y	N	Y	N	Y
8	2.1	-	-	-	-	-
9	14.6	-	-	-	-	-
10	114.6	-	9.8	-	1.1	-
11	221.5	95.7	42.1	25.0	4.4	10.8
12	152.1	125.5	106.8	103.8	7.8	.0
13	50.0	110.6	112.0	140.4	8-9	10.8
14	62.5	21.3	82.0	159.6	6.7	43.2
15	0	6.4	51.1	103.8	3.3	.0
16	0	0	43.6	32.7	2.2	43.2
17	0	0	55.2	19.2	3.3	21.6
18	4.2	0	103.0	13.5	4.4	181.1
19	0	0	125.6	13.5	6.7	137.8
20	2.1	0	70.7	1.9	3.3	148.6
21	-	0	93.2	1.9	2.2	221.6
22	-	0	63.9	-	5.6	337.8
23	-	0	27.1	-	1.1	424.3
24	-	0	33.8	-	5.6	583.8
25	-	0	26.3	-	2.2	486.5
>25	-	6.4		-		
Total	558.3	1310.6	1503.8	615.4	78.9	5627.0
Age 1+	488.2	331.8	300.8	403.8	23.4	54.0
Age 2+	4.2	-	299.3	17.3	14.4	508.0

Table 19. Chi-square tests of catch rates (nos./h), by area, depth, and year of selected age-classes of English sole and rock sole caught by trawls with (Y) and without (N) a small-mesh cod-end liner on South Moresby Bank, August 1981 and April 1981 and 1983.

Year	Depth (fath)	No. of Hauls N	No. of Hauls Y	Age (y)	Catch rate (nos./h) N	Catch rate (nos./h) Y	χ^2[a]	P
					English sole			
1983	20-29	1	1	All	558.3	1310.6	303	<.01
				+1	488.2	331.8	30	<.01
	40-49	4	1	All	1503.8	615.4	372	<.01
				1+	300.8	403.8	15	<.01
				2+	299.3	17.3	251	<.01
	50-59	2	1	All	78.9	5627.0	5395	<.01
				1+	23.4	54.0	12	<.01
				2+	14.4	508.0	466	<.01
					Rock sole			
1981	30-39	1	1	All	217.5	210.0	0.132	>.20
				1+	5.0	17.5	6.9	<.01
				2+	27.5	55.0	9	<.01
1983	10-19	2	4	All	436.6	100.6	210	<.01
	20-29	5	3	All	261.2	114.5	57	<.01
				2+	50.6	22.6	11	<.01
	40-49	1	1	All	149.6	82.7	19	<.01
				1+	12.0	5.7	2.242	>.10

[a] $\chi^2 = 4[N-(N+Y)/2]^2/(N+Y)$; Df=1.

Table 20. Length-frequencies (nos./h), by year and depth, of rock sole by trawls with (Y) and without (N) a small-mesh cod-end liner, on South Moresby Bank, August 1981 and April 1983.

Fork	Year:	1981		1983					
length	Depth (fath):	30-39		10-19		20-29		40-49	
(cm)		N	Y	N	Y	N	Y	N	Y
6		-	-	-	-	1.1	-	-	-
7		-	-	-	-	8.4	-	2.3[a]	-
8		-	2.5	-	-	24.1	-	0	-
9		2.5	7.5	-	0.6	19.1	1.1[a]	0	-
10		2.5	7.5	-	0	5.6	1.1	0	-
11		0	2.5	4.2[a]	0	11.8	0	0	-
12		0	0	0	1.7	15.7	2.2	1.5	1 9
13		0	2.5	0	2.2	15.2	5.4	6.0	3.8
14		0	2.5	0	3.3	18.0	11.8	4.5	0
15		2.5	12.5	4.2[a]	1.7	17.4	5.4	9.8	0
16		2.5	7.5	0	0	7.9	1.1	6.0	0
17		15.0	10.0	0	0	7.9	2.2	7.5	7.7
18		10.0	17.5	9.9	0	5.1	0.5	10.5	0
19		10.0	25.0	0	0	0.6	1.1	18.8	9.6
20		27.5	12.5	4.2	0.6	3.4	1.6	21.8	0
>20									
Total		217.5	210.0	436.6	100.6	261.2	114.5	149.6	82.7
Age 1+		5.0	17.5	4.2	0.6	51.6	1.1	2.3	-
Age 2+		27.5	55.0	4.2	7.2	50.6	22.6	12.0	5.7

[a]Arbitrary "modes" assigned to age groups.

Table 21. Inventory of comparable hauls, and numbers of length measurements of selected species, by haul, completed with (Y) and without (N) a small-mesh cod-end liner + tickler chain, on North Moresby Bank, August 1981.

Haul no.	Liner + Tickler	Date	Time (PDT)	Dur. (min.)	Depth (fath)	Nos. measured			
						English	Rock	Cod	Halibut
21	N	12	1312	22	51-49	102	-	-	2
22	Y		1401	22	51-49	252	-	-	-
40	N	15	0727	23	24-25	4	126	-	4
42	Y		0907	24	25-24	11	197	-	5
70	Y	19	1035	25	28-26	169	21	-	5
71	N		1122	25	28-25	25	-	-	5
72	Y		1230	25	28-27	37	4	-	4
73	Y	19	1342	25	49-51	3	1	40	2
74	N		1442	27	45-52	1	2	-	4

Table 22. Length-frequencies (nos./h), by haul, of English sole and rock sole caught by trawls with (Y) and without (N) a small-mesh cod-end liner + tickler chain on North Moresby Bank, August 1981.

Fork Length (cm)	Haul no:	English sole					Rock sole	
		21 N	22 Y	71 N	70 Y	72 Y	40 N	42 Y
7		-	-	-	-	-	-	2.5
8		-	-	-	-	-	-	0
9		-	-	-	-	-	18.3	7.5
10		-	-	-	-	-	26.1	4.8
11		-	-	-	-	-	39.1	6.3
12		-	-	-	-	-	33.9	15.0
13		-	-	-	2.4	-	10.4	12.5
14		-	-	-	0	-	5.2	10.0
15		2.7	2.7	-	0	-	2.6	12.5
16		0	0	-	0	-	10.4	15.0
17		2.7	2.7	-	4.8	4.8	13.0	22.5
18		0	2.7	-	24.0	4.8	10.4	20.0
19		16.4	16.4	-	55.2	12.0	2.6	10.0
20		19.1	54.5	7.2	67.2	5.4	13.0	25.0
21		27.3	65.5	2.4	52.8	21.6	7.8	17.5
22		5.5	68.2	7.2	50.4	4.8	5.2	7.5
23		5.5	51.8	2.4	28.8	0	10.4	2.5
24		21.8	62.7	9.6	24.0	0	0	7.5
25		5.5	32.7	2.4	21.6	4.8	5.2	5.0
>25		171.7	327.4	28.8	74.4	30.6	115.1	288.9
Total		278.2	687.3	60.0	405.6	88.8	328.7	492.5
Age 1+		-	-	-	-	-	99.1	33.7
Age 2+		-	-	-	-	-	33.8	57.5

Table 23. Chi-square tests of catch rates (nos./h), by haul, of selected age-classes of English sole and rock sole caught by trawls with (Y) and without (N) a small-mesh cod-end liner + tickler chain, on North Moresby Bank, August 1981.

Haul no.		Age	Catch rate (nos./h)			
N	Y	(y)	N	Y	χ^2 [a]	P
			English			
21	22	All	278.2	687.3	173	<.01
71	70	All	60.0	405.6	255	<.01
71	72	All	60.0	88.8	5.574	<.01
			Rock sole			
40	42	All	115.1	288.9	75	<.01
		1+	99.1	33.8	32	<.01
		2+	33.9	57.5	6.094	<.01

[a] $\chi^2 = 4[N-(N+Y)/2]^2/(N+Y)$; Df=1.

Table 24. Inventory of comparable hauls completed to compare catch rates of the survey (shrimp) trawl (N) and a commercial groundfish (Skagen) trawl (Y) on North Moresby Bank, August 1980

Haul no.	Skagen	Date	Time (PDT)	Dur. (min.)	Depth (fath)	Nos. measured			
						English	Rock	Cod	Halibut
1	N	11	1855	20	15-19	140	160	-	12
2	Y	11	1040	20	15-20	65	127	-	3
42	N	17	0955	15	16-15	7	21	-	1
43	Y	17	1050	15	14	-	122	-	2

Table 25. Length-frequencies (nos./h) of English sole and rock sole caught by survey (N) and commercial (Y) trawls on North Moresby Bank, August 1980.

Fork Length (cm)	Haul no. Skagen:	English sole 1 N	English sole 2 Y	Rock sole 1 N	Rock sole 2 Y	Rock sole 42 N	Rock sole 43 Y
9		-	-	3.0	-	4.0	-
10		-	-	18.2	-	0	-
11		-	-	15.2	-	4.0	-
12		-	-	9.1	-	4.0	-
13		-	-	0	-	0	-
14		12.1	3.0	3.0	-	0	-
15		35.4	3.9	39.4	-	0	12.0
16		75.8	6.1	33.3	-	0	4.0
17		97.0	9.1	36.4	-	4.0	8.0
18		66.7	9.1	12.1	3.0	0	0
19		30.3	12.1	3.0	0	0	0
20		33.3	0	24.2	9.1	0	12.0
21		6.1	6.1	33.3	45.5	0	12.0
22		12.1	12.1	45.5	30.3	4.0	20.0
23		15.2	21.2	6.1	12.1	4.0	52.0
24		9.1	30.3	15.2	12.1	12.0	44.0
25		12.1	21.2	30.3	30.3	8.0	20.0
>25							
Total		424.2	197.0	484.8	384.8	84.0	488.0
Age 1+[a]		-	-	36.4	-	-	-
Age 2+[b]		23.9	21.2	75.7	-	-	-

[a]Age 0+ for English sole.

[b]Age 1+ for English sole.

Table 26. Chi-square tests of catch rates (nos./h) for selected age-classes of English sole and rock sole caught by survey (N) and commercial (Y) trawls on North Moresby Bank, August 1980.

Haul no.			Age	Catch rate (nos./h)			
N	Y	Species	(y)	N	Y	χ^{2a}	P
1	2	English sole	All	424.2	197.0	8.3	<.01
			2+	239.5	21.2	18.3	<.01
		Rock sole	All	484.8	384.8	1.2	<.01
42	43	Rock sole	All	84.0	488.0	28.5	<.01

[a] $\chi^2 = 4[N-(N+Y/2]^2/(N+Y)$; Df=1.

Table 27. Regressions of abundance indices ($\overline{CPUE}$ and $\overline{\sqrt{F_0}}$) of English and rock sole on Moresby Bank -- age-2 on age-1, by year-class, 1979-83. (Source: Appendix tables 7-14.)

Year class	English sole				Rock sole			
	$\overline{CPUE}$[a]		$\overline{\sqrt{F_0}}$[b]		$\overline{CPUE}$		$\overline{\sqrt{F_0}}$	
	Age 1	Age 2	Age 1	Age 2	Age 1	Age 2	Age 1	Age 2
1979	-	-	-	-	5.17	2.65	0.79	0.79
1980	3.21	14.7	0.85	0.84	2.77	6.43	0.77	0.59
1981	4.82	8.38	0.81	0.79	2.18	9.40	0.80	0.48
1982	10.3	30.3	0.77	0.75	2.66	5.51	0.81	0.44
1983	11.3	11.5	0.66	0.78	1.30	3.71	0.84	0.68
Regression parameters (age 2 on age 1)								
a	8.63		0.594		7.76		0.584	
b	1.02		0.254		-0.788		0.0149	
r	0.420		0.555		-0.433		0.00269	
R^2	0.18		0.31		0.19		0.00	

[a] $\overline{CPUE}$ = geometric mean nos./h, weighted by number of hauls among depth intervals on South and North Moresby Bank. See Appendix tables 7 - 10.

[b] $\overline{\sqrt{F_0}}$ = mean square root of zero-catch incidence weighted by numbers of hauls among depth intervals on South and North Moresby Bank. See Appendix tables 11 - 14.

Table 28. Regressions of abundance indices ($\overline{CPUE}$ on $\overline{\sqrt{F_o}}$) of English and rock soles on Moresby Bank, by year-class, 1980-85. (Source: Appendix tables 7-14.)

	English sole				Rock sole			
	Age 1		Age 2		Age 1		Age 2	
	$\overline{CPUE}$[a]	$\overline{\sqrt{F_o}}$[a]	$\overline{CPUE}$	$\overline{\sqrt{F_o}}$	$\overline{CPUE}$	$\overline{\sqrt{F_o}}$	$\overline{CPUE}$	$\overline{\sqrt{F_o}}$
1979	-	-	-	-	5.17	0.79	2.65	0.79
1980	3.21	0.85	14.7	0.84	2.77	0.77	6.43	0.59
1981	4.82	0.81	8.38	0.79	2.18	0.80	9.40	0.48
1982	10.3	0.77	30.3	0.75	2.66	0.81	5.51	0.44
1983	11.3	0.66	11.5	0.78	1.30	0.84	3.71	0.68
	Regression parameters ($\overline{\sqrt{F_o}}$ on $\overline{CPUE}$							
a	0.907		0.824		0.831		0.831	
b	-0.0181		-0.00208		-0.0102		-0.0424	
r	-0.885		-0.542		-0.567		-0.773	
R^2	0.78		0.29		0.32		0.60	

[a]See Table 27 for definition.

Table 29. Estimated biomass (1000s of fish) of age-1 and age-2 English sole and rock sole on Moresby Bank, at 10-59 fath of year-classes 1978-84.

Year class	Age 1			Age 2		
	South	North	Total	South	North	Total
			English sole[a]			
1979	815+[b]	805+	1620+	X	X	X
1980	197	231	428	246+	32	278+
1981	820	152	972	1538	136	1674
1982	1381	358	1739	74+	324+	398+
1983	440+	963	1403+	1783	464	2247
1984	2287	568	2855	X	X	X
Total	5940	3077	9017	3614	956	4597
%		34.1			20.6	
			Rock sole[c]			
1978	X	X	X	862	1152	2014
1979	271	468	739	144	197	341
1980	139	223	362	223	422	645
1981	168	171	339	909	377	1286
1982	232	171	403	447	404+	851
1983	22+	159+	181+	247	221	468
1984	105	71	176	X	X	X
Total	937	1263	2200	2832	2773	5605
%		57.3			49.5	

[a]Computed from data in Appendix tables 7-8.

[b]"+" indicates minimum estimate because entire species distribution not included.

[c]Computed from data in Appendix tables 9-10.

Table 30. Estimated biomass (1000s of fish) of age-2, -3, and -4 Pacific halibut on Moresby Bank, at 10-59 fath, of year-classes 1977-83. (Computed from data in Appendix table 15.)

Year-class	Age 2			Age 3			Age 4		
	South	North	Total	South	North	Total	South	North	Total
1977	X	X	X	360	323	683	X	X	X
1978	88	332	420	497	784	1,281	512	701	1,213
1979	0	137	137	89	720	809	(80)	(99)	(179)
1980	0	113	113	(0)	(7)	(7)	27	873	900
1981	(0)	(0)	(0)[a]	25	777	802	366	239	605
1982	0	32	32	0	138	138	X	X	X
1983	0	14	14	X	X	X	X	X	X
Total[b]	88	628	716	971	2,749	3,720	985	1,912	2,897
%		87.7			73.9			66.0	

[a]Anomalous CPUEs in 1983. See text.

[b]Excluding 1983 data.

Appendix table 1. Inventory of individual, usable hauls by depth and area, completed in Hecate Strait, August 1980.

Depth interval (fath)						
0-9	10-19	20-29	30-39	40-49	50-59	60-69
			South			
-	9	7	5	4	-	-
	10	15	13-14	12		
	16	18	22-23	26		
	19	24	25			
	21	33				
	28					
	31-32					
	34					
			North			
71	1- 2	3	62	45	67	-
74	36-40	41	69	49-50		
77-78	42	44		65-66		
80	54	46-48				
	56-61	51-52				
	63-64	55				
	70	68				
	72					
	75-76					
	79					

Appendix table 2. Inventory of individual, usable hauls by depth and area, completed in Hecate Strait, August 1981.

Depth interval (fath)						
0-9	10-19	20-29	30-39	40-49	50-59	60-69
			South			
-	1	2	5	28	6	-
	3	4	7- 8			
	9	10	11-12			
	13-14	15	27			
	17	26				
		29				
			North			
66	25	18	41	19-20	21-22	44
68	30	23	47	62	58	
	33	31-32	63	64	65	
	37-39	35-36				
	46	40				
	48-53	43				
	55	45				
	59-61	54				
	75	57				
	77	72				

Appendix table 3. Inventory of individual, usable hauls by depth and area, completed in Hecate Strait, April 1982.

Depth interval (fath)						
0-9	10-19	20-29	30-39	40-49	50-59	60-69
			South			
-	11-12	4	2	1	10	-
	17-19	9	5	6- 7	20	
	65-66	15	8	13		
	69	28-29	14	26		
		62-63	22			
		67-68	27			
			70			
			North			
-	32	24	39-41	25	55	-
	35	30-31	48			
	37	33-34	51			
	44-45	36	56			
	50	38	58			
	52	42-43				
	54	49				
	57	53				
	59-60	61				

Appendix table 4. Inventory of individual, usable hauls by depth and area, completed in Hecate Strait, April 1983.

Depth interval (fath)						
0-9	10-19	20-29	30-39	40-49	50-59	60-69
			South			
-	10-11	2- 3	7- 8	1	6	-
	49	9	13	5	48	
	51-52	12	54	14	61	
	63	15-16	58	18		
		50	59			
		53				
		55				
			North			
-	19	20-21	23	22	33	-
	30	24	26	25	44	
	32	27	28	39	56	
	34-35	29	31	45		
	40	36	37			
	42-43	41				
	47	46				

Appendix table 5. Inventory of individual, usable hauls by depth and area, completed in Hecate Strait, April 1984.

Depth interval (fath)						
0-9	10-19	20-29	30-39	40-49	50-59	60-69
			South			
-	2	3	1	-	-	-
	7	5	4			
	9	8	6			
	11-12	10	13-14			
		30-31				
			North			
-	17	16	-	15	28	-
	20	18-19		24		
	23	21-22				
	26-27	25				
	29					

Appendix table 6. Inventory of individual, usable hauls by depth and area, completed in Hecate Strait, April 1985.

Depth interval (fath)						
0-9	10-19	20-29	30-39	40-49	50-59	60-69
			South			
-	11	2	7-8	3	4	-
	15	5-6	17	10	9	
	49-50	14	52		13	
	66	16	74		19	
		18			51	
		48				
		64				
		65				
		70-72				
			North			
-	29	20	21	23-25	30	-
	32	27	26	28	34	
	40-41	31	37-38	35-36		
	44-46	33	47	57		
	56	39	55			
	58-59	42-43				
		54				
		60-63				

Appendix table 7. Geometric mean CPUEs (nos./h) of age-1 English sole on Moresby Bank, by year and depth, 1980-85. (Numbers of hauls in parentheses.)

Depth interval (fath)	Area (sq M)		1980	1981	1982	1983	1984	1985	Mean[a]
					South				
10-19	783	$\overline{CPUE}$	3.78	0	1.46	0	2.90	7.94	2.59
		(N)	(10)	(7)	(8)	(5)	(5)	(5)	(40)
20-29	197	$\overline{CPUE}$	23.3	2.09	4.52	2.71	4.69	2.83	4.79
		(N)	(4)	(6)	(11)	(12)	(6)	(15)	(54)
30-39	159	$\overline{CPUE}$	8.20	6.94	1.84	7.19	13.9	16.8	18.3
		(N)	(5)	(6)	(5)	(6)	(5)	(6)	(33)
40-49	182	$\overline{CPUE}$	6.42	5.00	6.64	46.9	UNK	49.7	24.5
		(N)	(3)	(1)	(5)	(5)	(0)	(2)	(16)
50-59	253	$\overline{CPUE}$	UNK	0	25.9	26.8	UNK	6.71	15.1
		(N)	(0)	(1)	(2)	(3)	(0)	(5)	11)
10-59	1321	$\overline{CPUE}$	8.69	2.82	5.02	12.6	7.01	18.7	9.90
		(N)	(22)	(21)	(31)	(31)	(16)	(33)	(154)
					North[b]				
10-19	517	$\overline{CPUE}$	14.1	1.77	0	2.91	11.6	1.98	5.88
		(N)	(14)	(12)	(6)	(10)	(6)	(9)	(57)
20-29	229	$\overline{CPUE}$	10.9	3.28	4.04	2.06	19.8	11.0	7.91
		(N)	(7)	(10)	(10)	(6)	(6)	(9)	(48)
30-39	73	$\overline{CPUE}$	0	0	12.9	0	UNK	29.54	11.4
		(N)	(1)	(3)	(5)	(3)	(0)	(4)	(16)
40-49	52	$\overline{CPUE}$	2.11	20.5	0	8.46	25.1	21.3	13.3
		(N)	(4)	(2)	(1)	(4)	(2)	(5)	(18)
50-59	36	$\overline{CPUE}$	UNK	3.00	0	55.3	0	5.00	19.8
		(N)	(0)	(1)	(1)	(2)	(1)	(1)	(6)
10-59	871	$\overline{CPUE}$	10.9	3.50	4.56	7.44	15.9	12.4	8.68
		(N)	(26)	(28)	(23)	(25)	(15)	(28)	(145)
					South + North				
10-59		$\overline{CPUE}$	9.89	3.21	4.82	10.3	11.3	15.8	9.31
		(N)	(48)	(49)	(54)	(56)	(31)	(61)	(299)

[a]Weighted by number of hauls.

[b]South of 54°15'N lat.

Appendix table 8. Geometric mean CPUEs (nos./h) of age-2 English sole on Moresby Bank, by year and depth, 1982-85. (Numbers of hauls in parentheses.)

Depth interval (fath)	Area (sq M)		1982	1983	1984	1985	Mean[a]
			South				
10-19	783	$\overline{CPUE}$	1.15	0	0	1.64	0.76
		(N)	(8)	(5)	(5)	(5)	(23)
20-29	197	$\overline{CPUE}$	3.51	1.16	1.35	1.24	1.80
		(N)	(11)	(12)	(6)	(15)	(44)
30-39	159	$\overline{CPUE}$	0	3.22	3.99	7.64	3.87
		(N)	(5)	(6)	(5)	(6)	(22)
40-49	182	$\overline{CPUE}$	7.92	42.4	UNK	5.10	21.8
		(N)	(5)	(5)	(0)	(2)	(12)
50-59	253	$\overline{CPUE}$	34.3	41.3	UNK	72.2	55.4
		(N)	(2)	(3)	(0)	(5)	(10)
10-59	1321	$\overline{CPUE}$	24.9	11.9	1.75	13.4	14.5
		(N)	(31)	(31)	(16)	(33)	(111)
			North[b]				
10-19	517	$\overline{CPUE}$	0	0	1.55	0	0.30
		(N)	(6)	(10)	(6)	(9)	(31)
20-29	229	$\overline{CPUE}$	0	0	5.66	0	1.10
		(N)	(10)	(6)	(6)	(9)	(31)
30-39	73	$\overline{CPUE}$	3.94	0	UNK	44.2	16.4
		(N)	(5)	(3)	(0)	(4)	(12)
40-49	52	$\overline{CPUE}$	0	6.22	36.4	4.21	9.89
		(N)	(1)	(4)	(2)	(5)	(12)
50-59	36	$\overline{CPUE}$	3.00	37.7	79.4	63.0	44.2
		(N)	(1)	(2)	(1)	(1)	(5)
10-59	871	$\overline{CPUE}$	0.99	4.01	60.7	9.32	14.2
		(N)	(23)	(25)	(15)	(28)	(91)
			South + North				
10-59	2192	$\overline{CPUE}$	14.7	8.38	30.3	11.5	14.4
		(N)	(54)	(56)	(31)	(61)	(202)

[a]Weighted by number of hauls.

[b]South of 54°15'N lat.

Appendix table 9. Geometric mean CPUEs (nos./h) of age-1 rock sole on Moresby Bank, by year and depth, 1980-85. (Numbers of hauls in parentheses.)

Depth interval (fath)	Area (sq. M)		1980	1981	1982	1983	1984	1985	Mean[a]
					South				
10-19	783	$\overline{CPUE}$	1.25	1.17	1.70	1.15	0	1.15	1.14
		(N)	(10)	(7)	(8)	(5)	(5)	(5)	(40)
20-29	197	$\overline{CPUE}$	4.74	1.62	2.77	2.04	1.35	1.14	2.02
		(N)	(4)	(6)	(11)	(12)	(6)	(15)	(54)
30-39	159	$\overline{CPUE}$	2.02	3.02	1.20	9.75	0	1.12	2.93
		(N)	(6)	(6)	(6)	(6)	(5)	(6)	(35)
40-49	182	$\overline{CPUE}$	6.00	0	0	0	UNK	0	0.80
		(N)	(2)	(1)	(5)	(5)	(0)	(2)	(15)
10-49	1321	$\overline{CPUE}$	2.53	1.80	1.71	3.17	0.51	1.06	1.87
		(N)	(22)	(20)	(30)	(28)	(16)	(28)	(144)
					North[a]				
10-19	517	$\overline{CPUE}$	5.02	2.20	1.98	3.21	2.95	1.08	2.93
		(N)	(14)	(12)	(7)	(10)	(6)	(9)	(58)
20-29	229	$\overline{CPUE}$	13.8	2.17	4.15	1.59	1.20	1.13	4.47
		(N)	(10)	(10)	(10)	(6)	(6)	(9)	(51)
30-39	73	$\overline{CPUE}$	0	15.3	1.84	0	UNK	0	3.35
		(N)	(1)	(3)	(6)	(3)	(0)	(4)	(17)
40-49	52	$\overline{CPUE}$	0	0	0	1.32	3.00	1.15	0.95
		(N)	(4)	(2)	(1)	(4)	(2)	(5)	(18)
10-49	871	$\overline{CPUE}$	7.18	3.48	2.77	2.04	2.21	0.95	3.28
		(N)	(29)	(27)	(24)	(23)	(14)	(27)	(144)
					South + North				
10-49	2192	$\overline{CPUE}$	5.17	2.77	2.18	2.66	1.30	1.01	2.58
		(N)	(51)	(47)	(54)	(51)	(30)	(55)	(288)

[a]Weighted by number of hauls.

[b]South of 54° 15'N lat.

Appendix table 10. Geometric mean CPUEs (nos./h) of age-2 rock sole on Moresby Bank, by year and depth, 1980-85. (Numbers of hauls in parentheses.)

Depth interval (fath)	Area (sq. M)		1980	1981	1982	1983	1984	1985	Mean[a]
					South				
10-19	783	CPUE	3.48	1.17	1.30	5.07	4.79	1.15	2.71
		(N)	(10)	(7)	(8)	(5)	(5)	(5)	(40)
20-29	197	CPUE	4.90	1.35	4.20	5.46	2.57	2.28	3.50
		(N)	(4)	(6)	(11)	(12)	(6)	(15)	(54)
30-39	159	CPUE	5.11	3.75	4.37	33.4	7.82	7.55	10.4
		(N)	(6)	(6)	(6)	(6)	(5)	(6)	(35)
40-49	182	CPUE	33.5	0	1.15	4.54	UNK	2.65	6.72
		(N)	(2)	(1)	(5)	(5)	(0)	(2)	(15)
10-49	1321	CPUE	6.91	1.94	2.95	11.2	4.90	3.23	5.29
		(N)	(22)	(20)	(30)	(28)	(16)	(28)	(144)
					North[a]				
10-19	517	CPUE	5.51	1.63	2.71	2.33	6.22	1.29	3.24
		(N)	(14)	(12)	(7)	(10)	(6)	(9)	(58)
20-29	229	CPUE	45.9	2.16	8.22	9.23	6.42	6.70	14.1
		(N)	(10)	(10)	(10)	(6)	(6)	(9)	(51)
30-39	73	CPUE	11.0	14.8	26.24	5.19	UNK	2.83	14.1
		(N)	(1)	(3)	(6)	(3)	(0)	(4)	(17)
40-49	52	CPUE	0	0	0	17.9	5.48	6.03	6.26
		(N)	(4)	(2)	(1)	(4)	(2)	(5)	(18)
10-49	871	CPUE	18.9	3.17	10.8	7.21	6.20[a]	4.20	8.75
		(N)	(29)	(27)	(24)	(23)	(14)	(27)	(144)
					South + North				
10-49	2192	CPUE	13.7	2.65	6.43	9.40	5.51	3.71	7.02
		(N)	(51)	(47)	(54)	(51)	(30)	(55)	(288)

[a]Weighted by number of hauls.

[b]South of 54°15'N lat.

Appendix table 11. Square root of zero-catch incidence ($\sqrt{F_0}$) of age-1 English sole on Moresby Bank, 1980-85.

Depth (fath)		1980	1981	1982	1983	1984	1985	Mean[a]
				South				
10-19	$\sqrt{F_0}$	0.77	1.00	0.94	1.00	0.77	0.63	0.86
	(N)	(10)	(7)	(8)	(5)	(5)	(5)	(40)
20-29		0.71	0.91	0.80	0.91	0.71	0.82	0.83
		(4)	(6)	(11)	(12)	(6)	(15)	(54)
30-39		1.00	1.00	0.89	0.71	0.63	0.41	0.75
		(3)	(6)	(5)	(6)	(5)	(6)	(31)
40-49		0.82	0.00	0.77	0.45	UNK	0.00	0.54
		(3)	(1)	(5)	(5)	(0)	(2)	(16)
50-59	$\overline{\sqrt{F_0}}$	-	1.00	0.00	0.00	UNK	0.77	0.44
	(N)	(0)	(1)	(2)	(3)	(0)	(5)	(11)
10-59	$\overline{\sqrt{F_0}}$	0.80	0.92	0.79	0.72	0.70	0.65	0.76
	(N)	(20)	(21)	(31)	(31)	(16)	(33)	(152)
				North				
10-19	$\sqrt{F_0}$	0.46	0.87	1.00	0.84	0.58	0.82	0.74
	(N)	(14)	(12)	(6)	(10)	(6)	(9)	(57)
20-29		0.65	0.77	0.84	0.91	0.82	0.67	0.77
		(7)	(10)	(10)	(6)	(6)	(9)	(48)
30-39		1.00	1.00	0.63	1.00	UNK	0.50	0.76
		(1)	(3)	(5)	(3)	(0)	(4)	(16)
40-49		0.87	0.71	1.00	0.71	0.00	0.45	0.61
		(4)	(2)	(1)	(4)	(2)	(5)	(18)
50-59	$\sqrt{F_0}$	-	0.00	1.00	0.71	1.00	0.00	0.57
	(N)	(0)	(1)	(1)	(2)	(1)	(1)	(6)
10-59	$\overline{\sqrt{F_0}}$	0.59	0.80	0.85	0.84	0.62	0.63	0.73
	(N)	(26)	(28)	(23)	(25)	(15)	(28)	(145)
				South + North				
10-59	$\overline{\sqrt{F_0}}$	0.68	0.85	0.81	0.77	0.66	0.64	0.74
	(N)	(46)	(49)	(54)	(56)	(31)	(61)	(297)

[a]Weighted by number of hauls.

Appendix table 12. Square root of zero-catch incidence ($\sqrt{F_0}$) of age-2 English sole on Moresby Bank, 1982-85.

Depth (fath)		1982	1983	1984	1985	Mean[a]
			South			
10-19	$\sqrt{F_0}$	0.94	1.00	1.00	0.89	0.96
	(N)	(8)	(5)	(5)	(5)	(23)
20-29		0.80	0.96	0.82	0.93	0.89
		(11)	(12)	(6)	(15)	(44)
30-39		1.00	0.82	0.89	0.71	0.85
		(5)	(6)	(5)	(6)	(22)
40-49		0.77	0.45	UNK	0.00	0.51
		(5)	(5)	(0)	(2)	(12)
50-59	$\sqrt{F_0}$	0.00	0.00	-	0.45	0.23
	(N)	(2)	(3)	(0)	(5)	(10)
10-59[a]	$\overline{\sqrt{F_0}}$	0.81	0.76	0.89	0.75	0.79
	(N)	(31)	(31)	(16)	(33)	(111)
			North			
10-19	$\sqrt{F_0}$	1.00	0.84	0.82	1.00	0.91
	(N)	(6)	(10)	(6)	(9)	(31)
20-29		1.00	0.91	0.82	1.00	0.95
		(10)	(6)	(6)	(9)	(31)
30-39		0.77	1.00	UNK	0.50	0.74
		(5)	(3)	(0)	(4)	(12)
40-49	$\sqrt{F_0}$	1.00	0.71	0.00	0.63	0.58
	(N)	(1)	(4)	(2)	(5)	(12)
50-59	$\sqrt{F_0}$	0.00	0.71	0.00	0.00	0.24
	(N)	(1)	(2)	(2)	(1)	(6)
10-59[a]	$\overline{\sqrt{F_0}}$	0.90	0.84	0.61	0.82	0.81
	(N)	(23)	(25)	(16)	(28)	(92)
			South + North			
10-59[a]	$\overline{\sqrt{F_0}}$	0.84	0.79	0.75	0.78	0.79
	(N)	(54)	(56)	(32)	(61)	(203)

[a]Weighted by number of hauls.

Appendix table 13. Square root of zero-catch incidence ($\sqrt{F_0}$) of age-1 rock sole on Moresby Bank, by year and depth, 1980-85.

Depth (fath)		1980	1981	1982	1983	1984	1985	Mean[a]
				South				
10-19	$\sqrt{F_0}$	0.95	0.93	0.87	0.89	1.00	0.89	0.92
	(N)	(10)	(7)	(8)	(5)	(5)	(5)	(40)
20-29		0.71	0.82	0.80	0.87	0.82	0.97	0.86
		(4)	(6)	(11)	(12)	(6)	(15)	(54)
30-39		0.91	0.71	0.91	0.58	1.00	0.91	0.83
		(6)	(6)	(6)	(6)	(5)	(6)	(35)
40-49	$\sqrt{F_0}$	0.71	1.00	1.00	1.00	UNK	1.00	0.96
	(N)	(2)	(1)	(5)	(5)	(0)	(2)	(15)
10-49[a]	$\overline{\sqrt{F_0}}$	0.87	0.83	0.87	0.83	0.93	0.94	0.88
	(N)	(22)	(20)	(30)	(28)	(16)	(28)	(146)
				North				
10-19	$\sqrt{F_0}$	0.71	0.82	0.65	0.71	0.58	0.94	0.75
	(N)	(14)	(12)	(7)	(10)	(6)	(9)	(58)
20-29	$\sqrt{F_0}$	0.63	0.84	0.71	0.82	0.91	0.94	0.80
	(N)	(10)	(10)	(10)	(6)	(6)	(9)	(51)
30-39	$\sqrt{F_0}$	1.00	0.00	0.82	1.00	UNK	1.00	0.76
	(N)	(1)	(3)	(6)	(3)	(0)	(4)	(17)
40-49[a]	$\overline{\sqrt{F_0}}$	1.00	1.00	1.00	0.87	0.71	0.89	0.91
	(N)	(4)	(2)	(1)	(4)	(2)	(5)	(18)
10-49[a]	$\overline{\sqrt{F_0}}$	0.73	0.74	0.73	0.80	0.74	0.93	0.78
	(N)	(29)	(27)	(24)	(23)	(14)	(27)	(144)
				South + North				
10-49	$\overline{\sqrt{F_0}}$	0.79	0.77	0.80	0.81	0.84	0.93	0.82
	(N)	(51)	(47)	(54)	(51)	(30)	(55)	(288)

[a]Weighted by number of hauls.

Appendix table 14. Square root of zero-catch incidence ($\sqrt{F_0}$) of age-2 rock sole on Moresby Bank, by year and depth, 1980-85.

Depth (fath)		1980	1981	1982	1983	1984	1985	Mean[a]
				South				
10-19	$\sqrt{F_0}$	0.77	0.93	0.94	0.45	0.00	0.89	0.71
	(N)	(10)	(7)	(8)	(5)	(5)	(5)	(40)
20-29		0.71	0.91	0.52	0.65	0.58	0.68	0.66
		(4)	(6)	(11)	(12)	(6)	(15)	(54)
30-39		0.82	0.58	0.58	0.00	0.45	0.58	0.50
		(6)	(6)	(6)	(6)	(5)	(6)	(35)
40-49	$\sqrt{F_0}$	0.00	1.00	0.89	0.45	UNK	0.71	0.61
	(N)	(2)	(1)	(5)	(5)	(0)	(2)	(15)
10-49[a]	$\overline{\sqrt{F_0}}$	0.70	0.82	0.71	0.44	0.36	0.70	0.63
	(N)	(22)	(20)	(30)	(28)	(16)	(28)	(144)
				North				
10-19	$\sqrt{F_0}$	0.65	0.87	0.76	0.77	0.41	0.94	0.75
	(N)	(14)	(12)	(7)	(10)	(6)	(9)	(58)
20-29	$\sqrt{F_0}$	0.00	0.84	0.45	0.41	0.58	0.47	0.45
	(N)	(10)	(10)	(10)	(6)	(6)	(9)	(51)
30-39	$\sqrt{F_0}$	0.00	0.00	0.00	0.58	UNK	0.71	0.27
	(N)	(1)	(3)	(6)	(3)	(0)	(4)	(17)
40-49	$\sqrt{F_0}$	1.00	1.00	1.00	0.00	0.71	0.45	0.59
	(N)	(4)	(2)	(1)	(4)	(2)	(5)	(18)
10-49[a]	$\overline{\sqrt{F_0}}$	0.45	0.77	0.45	0.52	0.53	0.66	0.57
	(N)	(29)	(27)	(24)	(23)	(14)	(27)	(144)
				South + North				
10-49[a]	$\overline{\sqrt{F_0}}$	0.56	0.79	0.59	0.48	0.44	0.68	0.60
	(N)	(51)	(47)	(54)	(51)	(30)	(55)	(288)

[a]Weighted by number of hauls.

Appendix table 15. CPUEs (nos./h) of age-2, -3, and -4 Pacific halibut, by depth and year, on Moresby Bank, 1980-85. (Numbers of hauls in parentheses.)

Depth interval (fath)	Area (sq M)	Age (y)	1980	1981	1982	1983	1984	1985
				South				
10-19	783	2	0	0	0	0	0	0
		3	0.46	0	0.28	0	0	0
		4	X	X	2.52	0.47	0	2.16
		(hauls)	(9)	(6)	(8)	(5)	(5)	(5)
20-29	197	2	2.00	0	0	0	0	0
		3	4.00	1.29	0.77	0	0.38	0
		4	X	X	2.05	0	0	0.60
		(hauls)	(5)	(6)	(9)	(8)	(6)	(13)
30-39	159	2	1.27	0	0	0	0	0
		3	3.16	10.85	1.03	0	0.58	0
		4	X	X	4.14	0.56	1.16	1.40
		(hauls)	(6)	(6)	(7)	(4)	(5)	(5)
40-49	182	2	0	0	0	0	-	0
		3	4.35	2.33	0.40	0	-	0
		4	X	X	2.38	0.50	-	2.47
		(hauls)	(3)	(1)	(5)	(4)	(0)	(2)
50-59	253	2	-	0	0	0	-	0
		3	-	3.77	0	0	-	0
		4	X	X	0	0	-	0
		(hauls)	(0)	(1)	(2)	(2)	(0)	(5)
				North				
10-19	527	2	2.89	0.81	0.22	0	0.41	0
		3	1.44	3.36	5.59	0	9.13	0.93
		4	X	X	6.88	0.27	10.37	0.70
		(hauls)	(21)	(19)	(11)	(8)	(6)	(10)
20-29	238	2	3.04	2.11	0	0	0	0.40
		3	3.04	10.07	4.52	0	1.88	1.20
		4	X	X	2.64	0.32	1.41	3.21
		(hauls)	(10)	(11)	(12)	(8)	(6)	(12)

Appendix table 15 (cont'd)

Depth interval (fath)	Area (sq M)	Age (y)	1980	1981	1982	1983	1984	1985
					North			
30-39	94	2	0	0	6.90	0	-	0
		3	0	4.30	9.05	0	-	0
		4	X	X	5.17	2.00	-	0.40
		(hauls)	(2)	(3)	(6)	(5)	(0)	(6)
40-49	71	2	0	0	0	0	0	0
		3	1.79	6.25	0	0.62	0	1.39
		4	X	X	0	3.70	1.54	4.53
		(hauls)	(5)	(4)	(1)	(4)	(2)	(7)
50-59	52	2	0	0	0	0	0	0
		3	11.11	5.45	0	0	0	1.19
		4	X	X	0	0	0	2.38
		(hauls)	(1)	(4)	(1)	(2)	(1)	(2)

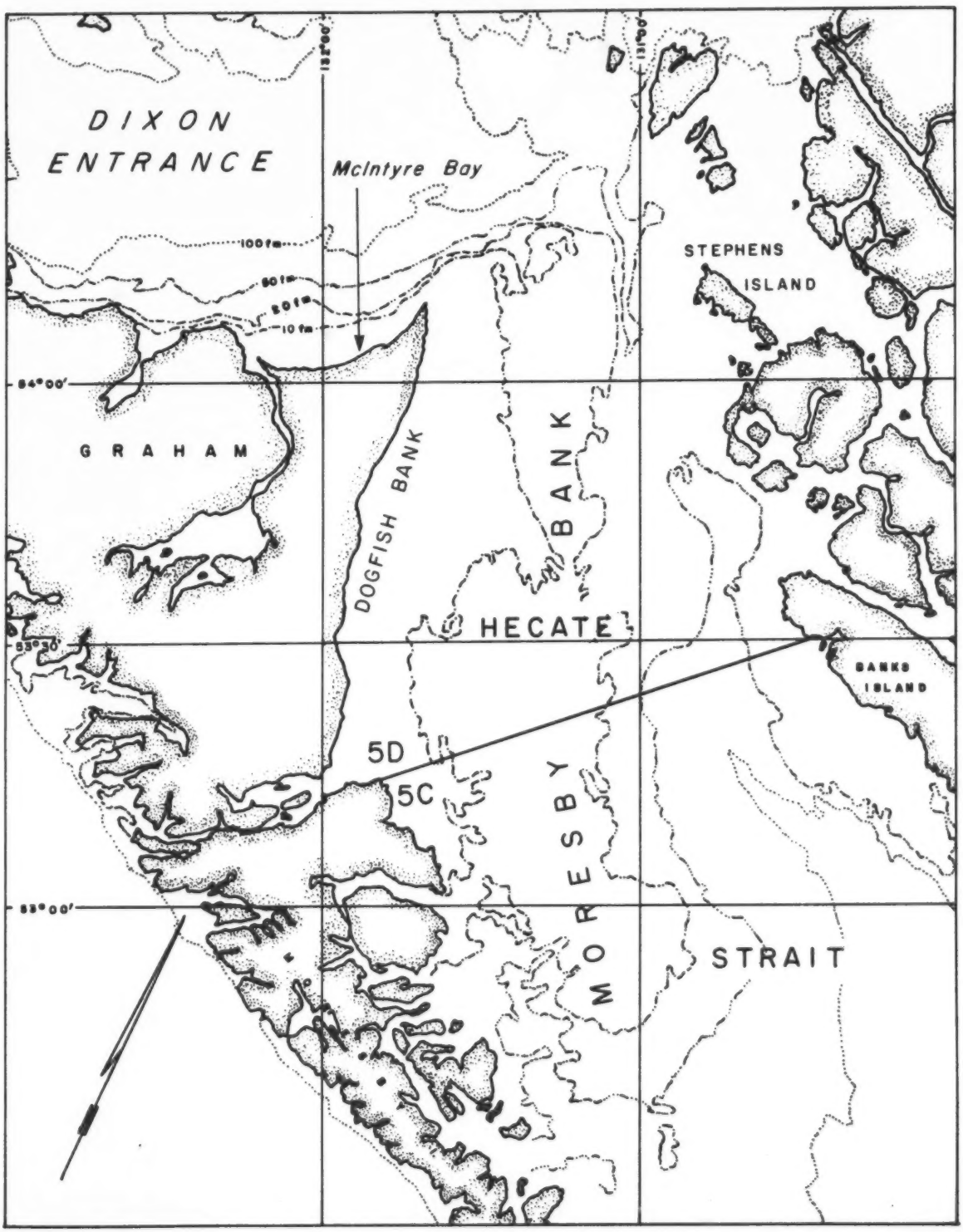

Figure 1. Bathymetric chart of Hecate Strait and Dixon Entrance.

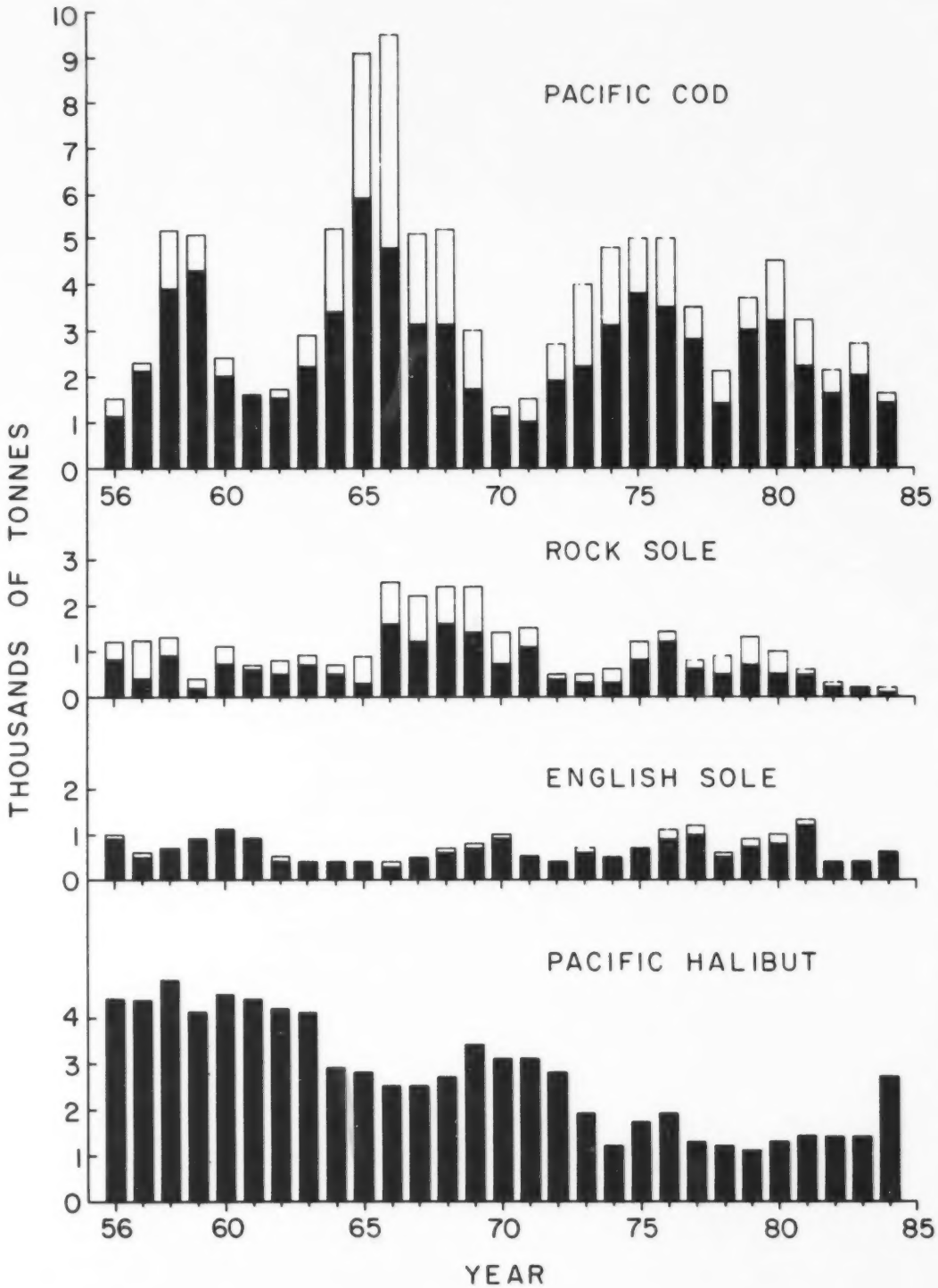

Figure 2. Canada-U.S. landings (t) of trawl-caught Pacific cod, rock sole, and English sole; and line-caught Pacific halibut; from Hecate Strait and Dixon Entrance (Areas 5C + 5D), 1956-84. (For trawl-caught species, shaded areas represent landings from Area 5D).